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A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING.

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THE EFFECTS OF A CONTROLLED THERMAL ENVIRONMENT ON PUPIL LEARNING WERE ANALYZED. APPROXIMATELY 20 MATCHED PAIRS OF FIFTH-GRADE STUDENTS WERE SELECTED. TWO GROUPS WERE USED--ONE FOR AN IDEAL THERMAL ENVIRONMENT AND THE OTHER FOR A DEVIATE THERMAL ENVIRONMENT. THE STUDENTS WERE MATCHED BY INTELLIGENCE TEST SCORES, ACHIEVEMENT TEST RESULTS, SEX, AGE, AND FAMILY BACKGROUND. THE CLASSROOMS WERE IDENTICAL IN ALL PHYSICAL ASPECTS. TEACHING INSTRUCTION FOR BOTH GROUPS WAS IDENTICAL, AND A WEEKLY ACHIEVEMENT SCORE WAS COLLECTED FROM ALL PARTICIPATING STUDENTS. THE STUDY LASTED ALMOST NINE SCHOOL WEEKS. RESULTING DATA WAS STATISTICALLY ANALYZED USING VARIANCE PROCEDURES. THE CONCLUSION REACHED BY THIS STUDY WAS THAT STUDENT LEARNING IS NOT AFFECTED BY ATTENDING SCHOOL IN A CONTROLLED IDEAL THERMAL ENVIRONMENT. (JH)

J0-415

A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING

Cooperative Research Project No. 5-8308-2-12-1

Burdette P. Hansen
University of Iowa
Iowa City, Iowa

1966

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A STUDY OF THE EFFECTS OF ROOM TEMPERATURE ON LEARNING

by

Burdette P. Hansen

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Education State University of Iowa

February 1966

Chairman: Professor Willard R. Lane

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CHAPTER I

THE PROBLEM

The purpose of this chapter is to (1) explain the objective of the study, (2) state the problem, both in general terms and more specifically in a null hypothesis, (3) establish a need for the study, (4) state the purpose of the study, and (5) to define the terms used throughout the study.

Objective

This study was concerned with analyzing the effects of a controlled thermal environment on pupil learning.

The research was specifically designed to determine if pupils attending school in a controlled model thermal environment attained statistically significant greater learning than did pupils attending school in a controlled non-model thermal environment. This study was designed in such a way as to ensure that other factors affecting pupil learning would be controlled. In this manner, it was possible to definitely determine the educational benefits achieved by a controlled model thermal environment.

Statement of Problem

The professional literature abounds with statements about the educational value of thermal controlled environment in the classroom. A very positive statement concerning the value of a thermal environment was made by Frye: "In fact, educators have known for several decades there is a close correlation between comfort and learning."[1] A strong case was made for school air conditioning by Mark Hampton, architect, from Tampa, Florida. Hampton states, "The whole reason for air conditioning is that the child in the classroom will be better able to concentrate, and the teachers will be better able to teach."[2]

However, the National Council on Schoolhouse Construction in their 1965 Guide for Planning School Plants did not make as conclusive a statement concerning the value of a controlled thermal environment:

> Research has not established a definite relationship between learning and various thermal conditions, but many authorities imply

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1 R. A. Frye, "See More - Hear More - Learn More in Windowless Rooms," Education Screen and Audio-Visual Guide, 40, 274-7.

2 Henry Wright, "Architects Consensus: Air Conditioning, Yes, Windowless School "No," Nation Schools, 74:62-3, October 1964.

that one exists.[3]

The problem examined in this study was to compare students' learning achievement in a controlled model thermal environment with students' learning achievement in a controlled non-model thermal environment. For the sake of clarity the controlled model thermal classroom has been referred to as the ideal thermal environment; the controlled non-model thermal classroom is termed the deviate thermal environment.

To be more specific, the following hypothesis was tested in this study:

H: There is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment.

Need For the Study

Education is now of national concern. National legislation of the past few years can be used to point out the nation's growing concern for providing better educational opportunities in this country. This nation, through various programs, is attempting to improve the education of its citizens.

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3 National Council on Schoolhouse Construction, Guide For Planning School Plants, AASA, 1965, p. 112.

One way to improve the present education program is by increasing the learning efficiency of all students. It seems clear that if a method of increasing students' learning efficiency can be found, it would be to this country's interests.

It is the purpose of this study to statistically measure whether children learn more efficiently in an environment that is considered ideal, than in a deviate environment. It was believed that this study, the third in a series of such studies conducted at the State University of Iowa, would permit generalizations about the learning of pupils in an ideal thermal environment as opposed to learning in a deviate environment.

This country has the industrial knowledge to construct classrooms with controllable thermal environments. Each year more and more school buildings are constructed with a controllable thermal environment. As far back as 1961 the following statement appeared in the October issue of Overview: "Almost three new educational buildings are being completed every day with full or partial air-conditioning."[4]

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[4] _____, "Air Conditioning and the Learning Environment," Overview, 2:50-3, October 1961.

Not all school buildings presently being constructed include provisions for a controlled thermal environment. Obstacles remain in the way before a controlled thermal environment will be provided in every newly constructed school building:

> Two major obstacles still seem to stand in the way of the universal provision of school air-conditioning. First, neither all educators nor all architects have fully accepted the availability and financial practicality of systems controlling high temperature and humidity. Second, boards of education, trustees, and lay citizens are still not fully aware that air-conditioning brings actual increases in building use and educational effectiveness.[5]

It was not the purpose of this study to research the cost of providing a controlled thermal classroom environment. However, since cost is one of the major obstacles retarding the providing of a controlled classroom thermal environment, it is examined briefly.

The experience of the Omaha Public Schools in constructing air-conditioned classrooms is reported in Table I.

Manning wrote: "In answer to the original query regarding feasibility of school air conditioning, the team concluded: air conditioning can be installed in schools for little additional cost over heating alone, providing the

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5 Ibid.

TABLE I
COMPARATIVE COSTS OF AIR-CONDITIONED AND
CONVENTIONAL JUNIOR HIGH SCHOOLS
OMAHA, NEBRASKA[3]

Bid Date	Air Cond.	Student Cap.	Total[1] Cost	Total Sq. Ft.	Cost per Sq. Ft.	Cost per pupil
Jan-57	No	1350	2,179,580	142,000	15.35	1,614.00
Oct-57	No	1350	2,230,[illegible]19	152,800	14.60	1,652.00
Sep-62[2]	No	1200	1,971,9[illegible]7	128,720	15.32	1,642.00
Sep-63	Yes	1200	2,079,747	133,[illegible]7[illegible]	15.66	1,731.00
Oct-63	Yes	1200	1,960,615	12[illegible],830	15.72	1,634.00
Feb-64	Yes	1200	1,927,500	1[illegible]8,830	15.[illegible]	1,606.00

[1]Exclusive of site costs and site develo[illegible] and

[2]Does not have cafeteria pool, all others do

[3]Records of the Omaha Public Schools.

school is designed for it."[6]

Therefore, it does appear that some evidence has been compiled to overcome the cost obstacle of providing a controlled classroom thermal environment. However, very limited research evidence has been collected to overcome the second obstacle.

Purpose of the Study

Does providing an ideal controlled thermal environment in the classroom increase students' achievement? It is felt this research collected evidence which will help to answer that question.

The Textile Industry reported:

> The textile people found that when you create good temperature and lighting conditions, and control humidity in textile mills, not only do people perform better and produce more, they also produce a higher quality of product.[7]

Studies involving control and experimental groups with varied thermal environments, with the exception of University of Iowa studies, do not exist. Other areas of the public sector have studied the benefits of having their

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6 William R. Manning and Lionel R. Olsen, "Air Conditioning: Keystone of Optimal Thermal Environment," American School Board Journal, 149:22-23, August 1964.

7 ....., Nation School, 74:62-3, op. cit.

employees work in a controlled thermal environment:

> In 1957, however, a five-month study conducted by the Office of Buildings Management, General Services Administration, indicated workers in air conditioned spaces have a 9.5 percent greater output than do workers in similar spaces without air conditioning. The study also revealed that there is a 2.5 percent less absenteeism among workers in air conditioned spaces.[8]

It was the purpose of this study to find out if similar greater output might occur among students if they were educated in a controlled ideal thermal classroom environment. Output was defined as stucent achievement.

Definition of terms

A controlled ideal thermal environment is, for purposes here, an environment considered as ideal by thermal authorities. The environment that was considered as ideal will be described in detail in Chapter III.

A controlled deviate thermal environment is an environment considered non-optimum by thermal authorities.

Student learning was defined as achievement in teacher-made tests.

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8 _____, "Thermal Comfort and Efficiency," Overview, 3:23, August 1962.

CHAPTER II

REVIEW OF RESEARCH AND LITERATURE

The purpose of this chapter is to extensively review the research and literature concerning the effect of a controlled ideal thermal environment on students' achievement. First an analogy is given of a controlled thermal environment and air conditioning. This is followed by a review of the research and literature in both education and engineering relative to the effects of an ideal thermal environment on achievement. The effect of environment on health is examined briefly. Next a look is given to some historical comments on the effect of a proper thermal classroom environment. A report of thermal conditions necessary before the installation of a mechanical cooling unit in school buildings is then examined. This is followed by a summary of the findings of the previous University of Iowa studies and the Pinellas County, Florida, experiment. The chapter is concluded with a summary of various authors statements of needed research relative to measuring the effect of an ideal thermal environment on students' achievement.

Thermal Environment and Air Conditioning

This paper will use the term thermal environment when referring to all thermal conditions that would affect students' comfort. A preponderance of writers used the more popular term air conditioning to mean the same thing:

> What is air conditioning? The American Association of Heating, Refrigeration and Air Engineers defines it as "the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space."[1]

Although it may be true that many people associated the phrase air conditioning with the cooling of air, air conditioning is more than the cooling of air. Because of the wide acceptance of the idea of air conditioning most writers used the term rather than controlled thermal environment. However, the writers in the field used the definition of the American Association of Heating, Refrigeration and Air Engineers, rather than the more limited definition - cooling of air.

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[1] W.D. Foutz, "Comfortable Climatic Conditions in School Buildings," National Council on School Construction, Proceedings of the Thirty-ninth Annual Meeting, Denver, Colorado, October 1962, pp.66-70.

Education Literature

Many authors in the professional educational field state that a controlled ideal environment will improve learning. Examples of these writings follow:

> Teachers have remarked: People laugh and say that the air conditioned school is for the benefit of teachers, but we say it is for the benefit of education. Children used to be hot, tired, and soaked in perspiration; now they are alert and attentive all day.[2]

> The school plant under consideration has been in usage throughout all four seasons. Teachers' comments indicated that their effectiveness and comfort increased as well as student learning. Some evidence exists to indicate that absenteeism was reduced, both student's and teacher's, due to lowered transmission of germs and disease.[3]

> But air conditioning's real value is in terms of educational productivity, the important - albeit hard to measure - goal.[4]

> Although we have not yet collected a body of evidence to prove it, we know that young people learn better when environmental conditions are right for them. Air conditioning may be considered as one of the components.[5]

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2 Harold C. Brantley, "United High School, Laredo, Texas," American School Board Journal, 148:65-68, June 1964.

3 Manning, op. cit., pp. 22-23.

4 _____, Overview, op. cit., October 1961, pp. 50-53.

5 John Lyon Reed, "Architects Consensus: Air Conditioning: Yes, Windowless School: No," Nation Schools, 74:62-3, October 1964.

From the above quotations one can readily observe that the authors of these articles implied that an ideal thermal environment does improve students' learning. However, none of the articles contained research data to substantiate their implications. These implications were not limited to those writing in periodicals. Mincy in his dissertation stated as one of his assumptions, "the thermal environment of a school is one of the environmental factors which affects, to a certain extent, the teacher-learning process."[6] Mincy did not attempt to measure the effect of the environment on learning.

The 1962-63, 34th edition of the American School and University contained two articles that implied that a positive relationship exists between the thermal environment of a classroom and learning. Both Lawrence Slote and Maurice J. Wilson in their articles in the 34th edition of this publication wrote about this relationship.

Slote explained:

> The application of air conditioning is an obvious and important aspect of human comfort in school and college buildings. Air conditioning is mainly concerned with the correction of

---

6 H.F. Mincy, "A Study of Factors Involved in Establishing A Satisfactory Thermal Environment in the Classroom," Unpublished Doctorial Dissertation, University of Tennessee, Knoxville, 1961, p. 3.

> abnormal atmospheres and the consequent promotion of comfort, health and efficiency.[7]

Slote, after advising the maintenance of a proper classroom thermal conditions for comfort, health, and efficiency, quoted Charles D. Gibson of California:

> Charles D. Gibson, Chief of the Bureau of School Planning, California State Department of Education has stated, "Thermal comfort is not a luxury. It is a physical and mental requirement for effective use of a classroom. Schoolroom discomfort means inattention, restlessness, poor behavior habits and a minimum of ability to maintain attention to any mental task."[8]

Wilson in his article stated that air conditioning was being purchased because it provides better learning conditions:

> Air conditioning of educational buildings at the elementary, secondary and college levels is proceeding at a pace educators, architects and taxpayers would have thought preposterous five years ago. Basically, air conditioning is being purchased because it provides better teacher-learning conditions.[9]

Wilson continued by citing both the number of schools air conditioned in 1960 and the reasons why they

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7 Lawrence Slote, "Achieving Thermal Comfort in Educational Building." American School and University, 1962-63, 34th edition, p. C1.

8 Ibid., p. C1.

9 Maurice J. Wilson, "Trends in Air Conditioning for Schools and Colleges," American School and University, 1962-63, 34th edition, p. C5.

were built with a controllable thermal environment:

> The 1960 American School and University Construction Census release showed that 9[illegible] schools and college buildings completed in 1960 were partially or completely air conditioned.
>
> Investigation into the reasons for air conditioning any one school will uncover three or four motivations. Improvement of learning and teaching efficiency and effective use of the educational plant for a longer portion of the year are perhaps the strongest reasons.[10]

Archibald B. Shaw while editor of Overview, in an editorial wrote:

> Learning is the activity in an educational plant; education is the product. The plant exists to promote learning. When this becomes clear, we can easily visualize the difference it makes when a sweaty student, struggling with sticky papers, is transformed into a cool and comfortable person at work in an environment that supports rather than detracts from his learning.[11]

In a different issue of Overview, another article discussed the relationship between an ideal thermal environment and efficiency, noting that research in the area was limited. The article stated, in part:

> . Thermal Human Comfort is one factor in student efficiency. Though research in the area is limited, empirical observation bears

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10 Ibid., p. C6.

11 Archibald B. Shaw, "Lag in Air Conditioning", Overview, December 1962.

> out this statement. We know, for instance, that schoolroom discomfort breeds inattention, restlessness, and poor behavior and results in a lessening of mental retention.[12]

Superintendent of Schools, Edwin Estell was quoted in School Management as follows:

> To my way of thinking no one really knows what all the advantages of air conditioning are. The possibilities that exist in an air conditioned school are just beginning to be opened up.[13]

Superintendent Estell has several air conditioned schools in his school district. Mr Estell is the District Superintendent of the Metropolitan School District of Lawrence Township, Indianapolis, Indiana.

Those writing about the effect of a controlled thermal environment on learning were not limited to the field of education. Henry Wright, former editor of Architectual Record quoted a statement by Architect John Lyon Reed: "We know that young people learn better when environmental conditions are right for them."[14]

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12 _____, "Thermal Comfort and Efficiency," Overview, August 1964, p. 25.

13 _____, "How to Take Advantage of Air Conditioning," School Management, July 1962, p. 92.

14 Henry Wright, "Air-Conditioning, Architecture, and Education," Architectual Record, August 1964, p. 145-150.

A recent development in the building of new education facilities has been the "underground" school. When a schoolhouse is constructed entirely underground it is necessary to completely control the environment of that building. Obviously such buildings have been the topic of much discussion and evaluation:

> In a recent survey, my recorded notes show that such schools (underground with a controlled thermal environment) had more places to display things, were dust free, had fewer disturbances, were thermally comfortable, were visually balanced, were less fatiguing, induced more stimulating learning, and were less expensive to operate and maintain. Teachers reported the children were learning more than they ever did under conventional class disturbances.[15]

The article failed to state upon what basis the teachers reported the children were "learning more than they ever did" under conventional class disturbances. Perhaps the teachers expressed this opinion because the pupils' behavior was better. In fact, Dillard reported this as one of the advantages of such a school. "Student behavior was better in the windowless wing (which was air conditioned)

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15 George J. Collings, "Evaluation of Windowless Classrooms," National Council on Schoolhouse Construction, Proceedings of the Thirty-eighth Annual Meeting, Atlanta, Georgia, October 1961, p. 59.

than in the conventional wing."[16] Appearing in the same article, the entire justification for the windowless (which must be air conditioned) school was improvement in work output.

> We all know - and this is the entire justification of the windowless school - that people do their best work when free from body stress and physical discomfort.[17]

Other authors have written about other advantages of air conditioning:

> Superintendent Taylor recalls: During summer school we almost had to chase the students outdoors. They (the students) know that they are going to school in comfort and they take a lot of pride in it.[18]

McQuade wrote a book Schoolhouse, in which he told of some of the problems involved in air conditioning:

> Ventilation needs are closely tied to acoustical needs, generally contradicting. Frequently you want to close a building up for acoustics, but open it up for circulation.[19]

McQuade stated that the teacher's comfort as well

---

16 Philip H. Dillard, "No Windows, Please . . .And Put It Underground," Audio-Visual Instruction, October 1962, 7:534.

17 Ibid., p. 535.

18 ____, School Management.

19 Walter McQuade, Schoolhouse, Simon and Schuster, New York, 1958, p. 149.

as the student's comfort was vital for the optimum learning.

> If the environmental conditions are not optimum, they (children) do something about it. Pity the teacher in a hot or cold classroom The class may pessmize (sic) her. Comfort - their comfort and hers - is not a luxury, but a physical and mental requirement.[20]

Manning and Olsen wrote that the teachers in an ideal thermal environment believe they are better teachers in such a classroom:

> Teachers' replies indicated that their effectiveness and comfort increase as well as student learning. Some evidence exists to indicate that absenteeism was reduced, both student's and teacher's, due to lowered transmission of germs and disease.[21]

Perhaps a thermal environment will increase students' achievement simply because students' attendance at summer schools will increase. Reported Brantley:

> Attendance is already better than last year, and enrollment has increased by twenty-five percent. The retention (better daily attendance) rate is also expected to be higher.[22]

One of the country's foremost educational consultants said, "All college buildings should be air con-

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20 Ibid., p. 175.

21 Manning and Olsen, op. cit., p. 23.

22 Harold C. Brantley, "United High School, Laredo, Texas," American School Board Journal, June 1964, p. 66.

ditioned for year-round use."[23]

Although many writing in educational publications implied that an ideal thermal environment would improve student achievement, they failed to identify research to substantiate their implications.

In recent years nearly all newly constructed commercial buildings have been equipped with controllable thermal environments. Why has this happened?

> Many business firms actually figure they save money by investing in air conditioning equipment -- their employees do better work if they are comfortable. In the same way, efficiency in learning may be the pay-off for cooling schools.[24]

Engineering Literature

Why have so many in the private sector of the economy air conditioned their factories? By seeking to find the answer to this question it was necessary to examine the literature of those who designed these factories:

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23 Engelhardt, Engelhardt and Leggett, "Educational Specifications for New College Facilities," A Study of Bulter County Community College, Bulter County, Kansas.

24 McQuade, op. cit., p. 186.

Cliff Cornell, Plant Engineer of Industrial Nucleonics, Columbus, Ohio, said: "Air Conditioning has proved to be so beneficial to us that we would not consider building a new plant without it."[25]

Eugene A. Sloane has done considerable research regarding the value of air conditioning in a factory:

> We found foremen, production supervisors and personnel directors raving about the benefits. We found foremen saying things like: I know production in my department went up 25 per cent after cooling, and that's conservative.
>
> In case after case, we heard work managers say: I don't know how we ever got along without air conditioning in the plant . . but I do know that we'd have to shut down now if it were shut off.
>
> With a 40 year life, a payout period of 6.2 years results. The approximate rate on return of investment in air conditioning is 16 per cent.
>
> Mr. August R. Bozzo, Vice President of Bulova Watch Co., Jackson Heights, New York, was most emphatic about the need for year-around temperature and humidity control. "We'd go out of business tomorrow without air conditioning."[26]

Sloane then listed sixteen reasons why a factory should be air conditioned:

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25 Eugene A. Sloane, "Why It Pays to Air Condition Factory Production Areas - Part II, "Air Engineering, February 1963, p. 35.

26 Eugene A. Sloane, "Why It Pays to Air Condition Factory Production Areas - Part I," Air Engineering, January 1963, pp. 22-44.

1. Increase employee efficiency, up to 10 per cent annually
2. Good return on investment in cooling system, up to 122 per cent
3. More production up to 70 percent
4. Better quality control fewer rejects - fewer errors - up to 30 per cent.
5. Maintenance savings, less dust, etc. - up to 50 per cent
6. Humidity control for comfort and process
7. Reduced absenteeism during hot weather - up to 20 per cent
8. Reduced training expense from labor turnover - up to 40 per cent less.
9. Reduced labor turnover
10. Fewer union grievances
11. More good will, morale
12. Better competitive position in labor market
13. Reduced accident rate
14. Longer life of plant facilities operating in clean, dry air at reduced operating temperature
15. Improved customer relations due to fewer field product failures.
16. Reduced hiring expense, personnel department cost.[27]

It is of interest to note that at least ten of these reasons could be a basis for providing a controlled thermal environment in the classroom.

Hospitals as well as factories are being air conditioned:

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[27] Ibid., p. 26.

> Toronto: A recent survey showed that the extra cost of full year round humidified air conditioning, both initial and operating, could well be repaid out of increased staff efficiency.[28]

Several authors writing in professional engineering magazines have attempted to make a strong case for air conditioning school buildings. One stated:

> In industry and commerce the fact that controlled thermal environment pays rather than costs is well accepted; but there exists a blind spot against such thinking on school authorities, and often vociferous, they maintain, a fully controlled thermal environment can contribute intimately to the efficiency and effectiveness of the educational process, and its application in schools can be defended and justified.[29]

Dr. Ciorciari wrote that air conditioning improves both the students' learning conditions and the teachers' efficiency:

> Research and observation of many years has established that the capacity for studying and retaining knowledge is higher when the students are in a stress-free body condition. Such a condition also enables teachers to give undivided attention to their classes and, thus, increase their efficiency.[30]

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28 _____, "Hospital Air Conditioning Pays for Itself, Survey Shows," Air Engineering, July 1966.

29 Robert C. Ring, "Thermal Environment for Schools," Heating, Piping and Air Conditioning, April 1966, pp. 109-111.

30 Dr. Marcello Ciorciari, "Air Condition Underground Buildings for Use as School or Shelter," Heating, Piping and Air Conditioning, June 1963, pp. 128-131.

Foxhall in the Architectual Record investigated the matter of students' learning in a controlled ideal thermal environment:

> Thermal comfort is not a luxury. It is a requirement for the philosophy and mental effective use of a classroom. Schoolroom discomfort means inattention, restlessness, poor behavior habits and a minimum of ability to maintain substained attention to any mental activity.[31]

Foxhall, although in an indirect way, admitted to a lack of research evidence showing the increased learning of youngsters attending thermal controlled classrooms:

> Many teachers are reluctant to state the effect of a good classroom environment on improving the grades achieved by students because of the difficulty of comparison with those in non-air conditioning schools.[32]

Foxhall did point out that due to lack of research concerning the effect of an ideal thermal environment on learning, air conditioning was being evaluated by non-scientific methods:

> Dr. Johnson (Superintendent of Schools) pointed out that the evaluation of air conditioning as a factor in school environment must be measured by the judgment of the teachers, the staff, the counselors, and the administrators.

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31 William B. Foxhall, "Air Conditioning for Schools," Architectual Record, July 1961, pp. 183-184.

32 Ibid., p. 184.

These judgments are based on many years of experience and seem valid although not statistically conclusive:

1. Attendance at the Eunice Smith School (which is air conditioned) is "a little better" than in the rest of the school system during warm months.
2. Achievement at the Eunice Smith School compares favorably with that in the rest of the school district.

Some factual conclusions are:

1. The teachers are happier.
2. Students and teachers do a better job in warm months.[33]

Writing in the Architectual Record Harold B. Gores approached the need for controlling the thermal environment of the classrooms in terms of (1) National Defense, (2) key facilities of depressed areas, and (3) the increased productivity of the students:

> Nowadays people have come to regard the schoolhouse as the new arsenal of national defense where the maximum possession of decency and knowledge by each and every pupil is its chief weapon in trade. If this be the case, then how the schoolhouse performs - how it encourages and speeds learning - takes precedence over how indestructible it is and whether it will live out its days in janitorial ease.
>
> The key facility for neighbor renewal in depressed areas is the schoolhouse, owned by everybody and serving everybody; the young by day, six days a week, and in the evening and on Saturdays, persons of all ages will gather at the school for educational, recreational or

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33 Ibid., p. 185.

> civic purpose. Because this facility will be working 4,000 hours a year, comfort of the occupants is as necessary to productive use as it is in any industrial or commercial property.
>
> Controlling the environment of the new school - or the old one for that matter - makes just as much sense for the school board as it does for any other corporate body concerned with the productivity of the occupants.[34]

Gores concluded the article with a statement of why controlling the thermal environment of the classroom was necessary:

> If learning is to be maximum, the young scholar needs to be protected from the enervating and distracting discomforts of an environment left to harsh and fickle nature.[35]

With the exception of the University of Iowa studies, only one study in which the effect of a controlled ideal thermal environment on students' achievement was reported. This study was not a tightly controlled research study; however its results were of interest:

> Another area of the study dealt with achievement of the students during two full academic years and two summer sessions. Pre and post tests were given for the various sessions and a comparison of the means of the scores were then expressed in mean gains. The

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34 Harold B. Gores, "The Case for Controllment of Environment," The Architectual Record, July 1961, p. 163.

35 Ibid., p. 163.

comparisons included grade level, the different schools, and results of the many subtests of the pre and post test batteries. There were 193 different comparisons over the two year sessions and those of air conditioned schools had greater mean gains in 133 comparisons. In none of the seperate comparisons were there gains that the researchers felt were statistically significant, yet in many incidences the trends were in favor of the climate controlled school.[36]

The matter of students' discipline was also given a cursory examination in this particular study:

> The research team did feel that through observations there were more discipline infractions in the non-climate controlled school but that it was more of a minor nature, such as disturbance and restlessness.[37]

The kinds and numbers of students illnesses were also studied:

> The actual difference in number and types of illnesses within the different schools were very slight. Therefore, there were no clear relationships obtained between the health of students and the climate of the school - yet this is not to say that there were not interesting trends in the data that reinforced other findings about climate controlled schools.[38]

There are those who believe, even though research is lacking, that providing an ideal thermal environment in

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36 _____, "To Compact is to Air Condition," Air Conditioning Heating and Ventilating, April 1964, pp. 66-69.

37 Ibid., pp. 66-69.

38 Ibid., pp. 66-69.

schools can increase student achievement. Some architects have sold boards of education on the value of air conditioning school buildings by the increase in students' learning such buildings would provide:

> On dealing with school boards, Mr. Hartstern said, "We didn't make any headway at all until we started talking to them about what air conditioning would do to the learning process."[39]

However, all school boards approving air conditioning in their school buildings did not state such a building will improve students' achievement. One of the largest air conditioned school buildings ever built in New York City contained 319,000 square feet at a cost of $7,500,000. The reasons given for air conditioning this school building did not include increased student learning:

> They (School Board and Superintendent) reasoned that it might become equally prevalent in school that a school built today without air conditioning or proper preparation for it may become obsolete long before it had served its expected useful life of 50 years or more.
>
> Additional arguments for complete air conditioning were the trend toward increased use of schools during the summer months for special and makeup classes and the possibility of a 12 month curriculum eventually becoming quite

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39 _____, "Symposium on Schoolroom Air Conditioning," Air Engineering, May 1962.

common.[40]

School districts that have school buildings with an ideal thermal environment have continued building them:

> This school (fully air conditioned) has prompted our office to take a careful look at air conditioning. We believe it will be the rule rather than the exception in the next few years.[41]

Health and the School Environment

Since this study was primarily concerned with the effect of an ideal thermal environment on students, it was necessary to examine the effect of a thermal environment on student health. It is generally accepted that the child who is unable to attend school regularly whether due to illness or other causes usually does not achieve well in school. A remark attributed to a survey team as they studied approximately 160,000 elementary Texas school children was: "If you want to keep your child healthy, don't send him to

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40 Lewis Smith, "Why and How a New High School is Being Fully Air Conditioned," Heating Piping and Air Conditioning, December 1962, p. 93.

41 _____, "School With Heat Pump, Fixed Glass," Architectural Record, July 1961, p. 172.

school."[42]

Thermal environment does have an effect on the health of indivicuals. T.C. Holy statec: "From the health angle, the incidence of respiratory disease is assumed to be related to the kinds of ventilation."[43]

Daugherty wrote directly about the issue of thermal environment and health:

> When air is dry, moisture evaporates more readily from the skin and produces a feeling of chilliness even with the temperature at 75 degrees or more. Dry air also removes moisture from the nasal passages and the throat causing that tight, irritated feeling that is so uncomfortable. Itchy skin is also a frequent result of dry air. Annoying, uncomfortable static electricity "shocks" multiply in dry air.
>
> Relative humidity maintained at 35 to 40 percent alleviates all of these problems and gives most people a feeling of comfort and well being at a temperature of 70 degrees.
>
> Research studies on Pneumococcus type I, the germ that causes pneumonia, Staphylococcocus albus and Streptococcus hemolyticus group C by the departments of medicine and biochemistry at the University of Chicago showed that relative

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42 Darrell Body Harmon, The Coordinated Classroom, The American Seating Company, Grand Rapids, Michigan, 1959.

43 T. C. Holy, "Location, Construction and Equipment of Schoolhouses for Health," American School Board Journal, January 1942, pp. 19-20.

humidifier [illegible] these circumstances [illegible] very humid air they survived much [illegible].

[illegible] in the field. [illegible] generally [illegible] very high humidities. [illegible] reduces susceptibility to colds and other respiratory disorders because moist membranes and throats are more resistant to the causes of these problems.[44]

Health, efficiency [illegible] by the thermal environment [illegible] article by Edward V. Costal:

[illegible] establish [illegible] human reactions [illegible] other conditions [illegible] mental energy [illegible] turn these [illegible] upon classroom activity.

Undoubtedly [illegible] in the school, as it is everywhere else, is the condition of the air.

Uncontrolled heat [illegible] fluctuations in temperature, [illegible] that amounts to nothing more than [illegible], and failure to provide correct cooling which is just as important as correct heating and ventilation -- all of these are costly.

From the student - teacher health and efficiency standpoint the cost is incalculable,

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44 Charles M. Daugherty, "Winter Humidification Key to Greater Comfort," American School Board Journal, August 1964, p. 44.

> as school administrators and boards well know. They also know, if there is a way to achieve acceptable classroom comfort the installation of any equipment that falls short of that goal is the poorest kind of dollar economy in first cost and in the cost of operation and maintenance.[45]

Historical Concern for Schoolroom Air

Controlling the thermal environment of a school building has been a rather recent development; however, concern over the thermal environment of the classroom is not. As early as 1832, William A. Alcott wrote an essay on the need for proper ventilation:

> Holes or windows should be made in the roof of every schoolhouse, that the impure air may sometimes be suffered to escape in that direction.
>
> At the present I will only add, that after every precaution in regard to ventilation, which human wisdom can devise, every pupil should be required, and, if necessary, compelled to go out into the open air, at least once in an hour. Probably once in half an hour is not too often.[46]

Mr. Alcott also reported failure to provide proper ventilation in classrooms as the great cause for

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45 Edward V. Dostal, "Providing for the Thermal Environment," American School Board Journal, January 1962, pp. 34-37.

46 William A. Alcott, "Essay on the Construction of Schoolhouses," Hilliard, Gray, Little and Wilkens, Boston, 1963, pp. 14-15.

teachers leaving the profession:

> In looking back upon the languor of fifty years of labor, as a teacher, reiterated with many a weary day, I attribute a great proportion of it to mephitic air; nor can I doubt that it has compelled many worthy and promising teachers to quit the employment. Neither can I doubt, that it has been the great cause of their subsequent sickly habits, and untimely disease.[47]

In the essay, Mr. Alcott expressed the feeling that it is inexcusable to make a child live in a poor classroom thermal environment:

> How preposterous and inexcusable would every one regard it, to give them (school children) their food constantly mingled with poison, or their drink with pernicious and loathsome insects. Yet it is not less inexcusable to furnish them with half corrupted air, or that which contains poisonous gasses! The food is given but three times a day; while the air is administered every moment. The child is at liberty to receive or reject food; but he is forced to breathe the air in which we place him.[48]

T. C. Holy took the following statement from the journal of Samuel Lewis, Ohio's first State Superintendent of Common Schools:

> The grounds on which the (school) house is built should be high, dry, removed from marshes, and stagnant water, not too near much traveled highways, yet having convenient access to it from every direction.

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[47] Ibid., p. 40.

[48] Ibid., p. 27.

> In towns and cities a lot should be selected, perhaps in the outskirts of the plat, certainly an open air situation, affording unobstructed light and air on all sides. This is much more necessary than is commonly supposed. If the house is dark, and ill ventilated, the children may be expected to be dull, and careless, and disorderly, and probably unhealthy.[49]

The above statement was written in the year 1838. During the years that followed a great deal of attention was given to providing the proper ventilation in the classroom:

> In the surge of school building that followed World War I much progress was made in improving thermal conditions in the classrooms. By 1929 the unit ventilator was the accepted standard.[50]

However, when the great depression settled over this country, schoolhouses were no longer constructed with unit ventilators. Unit ventilators were considered too "costly" to install in schoolhouses constructed during the depression.

Unit ventilators began to reappear in schoolhouses constructed following World War II. Beginning with the sixties, a few school buildings were air conditioned;

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49 Holy, op. cit., pp. 19-20.

50 W. D. Foutz, "Comfortable Climatic Conditions in School Buildings", National Council on School Construction, Procedings of the Thirty-ninth Annual Meeting, Denver, Colorado, October 1962.

most school buildings being built without complete thermal environment control had provisions for adapting the building to air conditioning should the need arise.

> There appears to be a definite trend in educational building toward providing more desirable environment air conditions whenever possible. This trend is growing out of a conviction on the part of educators that an atmospheric environment attuned to the student's needs pays indirect dividends in the form of better student-teacher relations, greater student satisfaction and comfort, and increased student efficiency in learning.[51]

Heating the schoolhouse is not the main problem in providing the ideal thermal environment in the classroom:

> Authorities are now in agreement that heating is no longer the central problem. Ventilation and cooling are the prime considerations in maintaining an optimal thermal environment.[52]

Mechanical Units Necessary

This section of the chapter presents the thermal conditions that are desirable to be maintained in a classroom. In the previous section it was stated that heating is no longer the central problem in providing the ideal thermal environment:

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[51] Slote, op. cit., p. C1.

[52] Manning and Olsen, op. cit., pp. 22-23.

> It appears to me that the problem of what the design criteria will be based around should be answered. So often as adults, we listen to a teacher's or principal's remarks and are affected mostly by statements that we derive from their conversations when actually our design criteria should be based entirely on the children. I think that we could answer the question by this statement: "The child should not be distracted by the condition surrounding him."[53]

The 1965 edition of the National Council on Schoolhouse Construction contains information that spelled out an ideal schoolhouse thermal environment and the necessity for such an environment.

> The human body is more than a thermometer that senses the temperature of its environment and reacts to it. Changes in temperature, air flow, or humidity calls for adjustments in elaborate body temperature with amazing accuracy.
>
> As the researchers agree on exact combination of radiant temperature, air temperature, relative humidity, and air movement that constitutes the optimum. The general optimum ranges suggested are: balanced mean radiant temperatures; approximate air temperatures ranging from 69° to 74° F., relative humidity between 40 per cent and 60 per cent; and air movement of 20 to 40 cubic feet per minute.
>
> The tendency to make errors increases as the effect of the warmer surroundings put a greater stress on human adjustment.

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53 Marvin R. A. Johnson, "Planning Thermal Comfort in Schooling Buildings," National Council on Schoolhouse Construction, Proceedings of the thirty-ninth Annual Meeting, Kansas City, Missouri, October 1959, pp. 27-30.

An optimum thermal condition at which most students are at their greatest efficiency is the object of a good thermal environment.

Optimum thermal conditions for students will vary according to their age, sex, level of physical activity, health, clothing density, and adaptation to local climate.

It is desirable, therefore, that average room surface temperature approximate room air temperature. To be somewhat more specific for an optimum environment with maximum learning efficiency in an occupied classroom; it is recommended that an air temperature of 71° F. be maintained when the mean radiant temperature (average temperature of surrounding surfaces) is at the same level as the air temperature. Deviations in the average surface temperature below (or above) air temperatures shall be compensated for by increasing (or decreasing) the air temperature in the ratio of 1.4° F. change in air temperature for every 1° F. change in average surface temperature.

Factors which influence comfort but which are not directly concerned with the production or removal of heat includes odors, dust, dirt, and other atmospheric contaminants such as smoke, exhause fumes and the like. These environmental and related factors should be controlled to the highest extent possible in order to provide satisfying thermal conditions.

Air motion within occupied space will, at the sitting level, provide air velocities ranging from 20 to 50 FPM. The air should be introduced into the occupied space in such manner that pockets of stagnant air are nonexistent. There should not be hot or cold air movements on occupants which cause discomfort.

All air supplied to occupied space should be passed through cleanable or replaceable air filters to reduce the air-borne dust.

> The relative humidity of a schoolroom should not be permitted to go below 25 percent nor above 60 percent.
>
> Sudden fluctuations of heating or cooling in room air temperatures due to equipment going on and off should not be more than ± 1° F., and preferably less.
>
> Room air temperature should not vary more than ± 1° F., vertically or horizontally up to the five foot level and to within one foot of exterior walls.[54]

If heating is no longer the central problem in providing the ideal thermal environment in the classroom, at what temperature is it necessary to cool the classroom air?

> When outside air is above 80 degrees classrooms are sure to be uncomfortable; even in northern cities in moderate weather classroom temperatures rise out of control.[55]

A study was conducted to discover when schoolhouse cooling was necessary:

> According to a study by John J. Nesbitt, Inc., year round air conditioning systems are justified in schools only if there is to be extensive use of classrooms at outside temperatures above 80° F., auditoriums at outside temperatures above 55° F., and offices at out-

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54 National Council on Schoolhouse Construction, op. cit., pp. 113-116.

55 Manning and Olsen, op. cit., pp. 22-23.

side temperatures of 75° F.[56]

Foutz reported the United States Government has set standards on when its buildings must be air conditioned:

> It is interesting to note the Federal Government handles air conditioning through the General Services Administration as follows: Whenever the Design Effective Temperature is above 80° F., buildings housing government employees must provide air conditioning, whether owned or rented by the government.[57]

Research has been conducted that permits a report on the percentage of time classrooms are in use when outside temperatures rises above 80° F. for various parts of the United States. Foutz continued:

> We went to United States Government figures on climatological data to determine what percentage of the hours the classrooms are in use when the outdoor temperature is above 80° F. We found some very interesting figures. In Los Angeles mechanical refrigeration is needed 33% of the hours. In other words, hardly a day goes by when mechanical refrigeration is not required if proper conditions in the classroom are to be maintained. In Washington, D.C. mechanical refrigeration is needed 44% of the time. And in Minneapolis - up in cold north country - nearly 25% of the school year is less effective if a school has no mechanical refrigeration. In Dallas, it's needed 62% of the classroom hours - well over half

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56 Harry Foutz, Mechanical-Electrical Equipment Handbook for School Buildings, John Wiley and Sons, Inc., New York, 1960, p. 210.

57 Foutz, op. cit., p. 69.

> of the school year. In Tampa, the percentage is 93%. In Jacksonville, Florida, 66% of the classroom hours are above 60° and are overheated invariably if the classrooms do not have mechanical refrigeration. In Chicago, 32% of the classroom hours are above 60°. In St. Louis 43% and in Cleveland, 34%. Mechanical refrigeration, then, has always been needed in schools throughout the country to obtain the maximum benefit from education the entire school year.[58]

One of the nation's largest manufacturer of heating and air conditioning equipment reported in its literature that students will profit greatly from an ideal thermal environment:

> Students experience roughly a 2% reduction in learning ability for every degree the room temperature rises above the optimum. Thus, for maximum learning efficiency, it is essential that adequate cooling as well as heating be provided in the classroom throughout the year.
>
> Air conditioning also improves attendance in the spring and fall months. Many absenteeisms results from the discomfort associated with overheating.[59]

As in other previous statements telling of the gains to be realized through an ideal thermal environment, no reference was given upon which the figures were based.

Slote summarized the problem of stating the criteria for selecting the proper mechanical units that are

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58 Ibid., p. 69.

59 _____, The Changing Pattern of Education and the Contribution of Air Conditioning, John J. Nesbitt, Inc., Philadelphia, Pa.

necessary to maintain the ideal thermal environment:

> It is impossible to set optimum air condition standards for all situations because the determinants which make up the standards or so-called comfort zone, are quite subjective. These determinants vary with age, sex, body build, clothing, activity, attitudes, and the adaptability characteristics of the individual.[60]

University of Iowa Studies

An extensive review of the literature revealed only one source of written research that was comparable to this study. This one study was conducted in joint co-operation by staff members of Educational Psychology and Educational Administration at the State University of Iowa, Lennox Industries Inc., and the Saydel, Iowa School District.

Peccolo's Study

Dr. Charles Peccolo was the researcher for this study. The study involved 44 matched pairs of fourth grade students and were divided into four groups. Each group was in the study for three weeks. Two groups were taught in the model environment and two groups in the regular (called marginal) classroom environment. Students in the model

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60 Slote, op. cit., p. C1.

classroom were referred to as the experimental group. The measuring tasks for his study consisted of a repeated series of ten paper and pencil tasks. The study was conducted from March 19, 1962 to May 1, 1962. The results of the study were:

> On the whole, the experiment showed large improvement on the part of every child taking part in 10 types of work. In every task, however, the experimental group which occupied the room with model thermal conditions, improved more than the control group. The results of the study were:
>
> 1. The significantly higher gains made by pupils in the experimental group indicated that the prescribed ideal thermal classroom environment was superior to the regular thermal environment for all reasoning and some clerical tasks.
>
> 2. The superiority of the experimental group on the new concepts task was not significant and may have been a chance difference.
>
> 3. The interaction between trials and levels and treatments indicated the prescribed ideal thermal classroom environment favored the experimental group in all the tasks, although the experimental effect varied in some tasks from level to level.[61]

McCardle's Study

A second study was conducted by Robert McCardle; however, the findings of this study have not been written as of this time. This experiment was conducted from

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61 Charles Peccolo, The Effects of Thermal Environment on Learning, The Iowa Center for Research in School Administration, Iowa City, 1962, p. 29.

October 15, 1962, through December 14, 1962. In this investigation the learning experiment was conducted with sixth grade pupils in a model and a regular (called marginal) thermal environment. Some programmed learning materials were used to insure equality of instruction.

As stated above the complete results of this study are not yet in research form. Some of the results of McCardle's study are available. These were announced at a thermal environment conference in Chicago. As a result of this conference the following statements were written, author not listed, in the April 1964, issue of the American School Board Journal:

> The model room students performed significantly better than those in the marginal room for tests administered in the morning. But in the afternoon, the marginal-room results were a little better than the model room results. The researchers also reported that the high-ability learners in the marginal room did somewhat better than the high-ability in the model room, but the low-ability learners in the model room did better than their counterparts in the marginal room.
>
> In the vocabulary tests, the model room students did better than those in the marginal room. In considering the number of errors made in the program, the marginal room was much higher in number of errors made, with the model room tending to go through the program making fewer errors.
>
> There were far more errors in the marginal room in the morning; 1.3 in the model room and 1.9 in the marginal room. In the afternoon there was not much difference in the performance of the

two, again indicating somewhat better performance in the afternoon than in the morning.

The high-ability learners in the afternoon in the model room made 1.4 errors, and the marginal learners made 1.1 errors. For the low-ability learners, the errors increased tremendously as you moved from the model to the marginal room.

It was also reported that in general the indications are that learning was more efficient in the model than in the marginal room, that the marginal environment seemed to have a more adverse effect on the low-ability learner than on the high-ability learner.[62]

Other Research

Pinnellas County Experiment

There is a dearth of literature regarding tightly controlled studies that have actually been completed concerning the effect of the thermal environment on learning. The Pinellas County, Florida, three year study did not control the learning experiences to which students were exposed. Although the Pinellas County study increased our knowledge about various aspects of a controlled thermal environment, generalizations concerning the effect of a model thermal environment on learning can not be made from

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62 _____, Press Conference Report, "Two Studies on Thermal Environment and Learning," American School Board Journal, December 1963, pp. 22-24.

this particular study.[63]

Needed Research

Several authors have noted that research measuring the effect of thermal environment on learning is needed. Concern over the absence of empirical data on the subject is apparent:

Mincy in his dissertation recognized the problem:

> Research in the area of the affect of the thermal environment upon learning has been rather limited.[64]

An article in Overview, author not given, said:

> Thermal human comfort is one factor in student efficiency. Though research in the area is limited, empirical observations bears out this statement. We know that school room discomfort breeds inattention, restlessness, and poor behavior and results in a lessening of mental retention.
>
> More statistical data relating air conditioning to student efficiency is also needed, not only to convince administrators of its importance, but because the thermal-conditioning system best for a particular school depends upon the kind of building, the climate, and the students involved. All of these factors must be weighed carefully before a thermal-comfort plan

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63 Fred Stuart and H.A. Curtis, The Pinellas County Experiment, Climate Controlled Schools, Cooperative Research Project No. 1067, ASHRAE No. R.P. 36, 1964.

64 Mincy, op. cit., p. 5.

is chosen. As things stand now, the school executive has little to base his air-conditioning decisions.[65]

The University of Michigan has conducted some related research in this area:

> The Department of Architecture at the University of Michigan reports that the University is conducting a case study on learning in windowless schools at Wayne, Michigan. The study, part of a larger research project supported by grants from the Education Facilities, seeks only to measure the importance of an outside view to the learning process.
>
> The report states that the larger study has so far been concerned mainly with a search of existing literature. The project finds the literature says much about the effect of light, heat, air, and sound on the physical comfort on students, but little on how or even whether physical comforts effect the learning process.
>
> Usually the question itself provokes the suggestion that a certain amount of discomfort may be essential to a good learning environment, the report continues. However, so far as we can discover, no one really knows or has even tried to find out. Indeed we find precious little agreement among educators and psychologists as to what constitutes the learning process itself; like many other humans, learning has always been taken for granted, and is now just beginning to be studied for its own sake.

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65 _____, Overview, August 1962, p. 25.

> The task of evaluating any school environment is admittedly very complex.[66]

Wilson writing under the heading "Needs of the Time" stated:

> Educators are under greater pressure than ever to provide optimum teaching programs for gifted, average and retarded students. All this at a time when enrollments are increasing fast, taxpayer resistance is high and competition for teaching talents is keen. The administrator must search every avenue for efficient use of his instructional staff, plant facilities, and teaching aids. Air conditioning can supply the answer to many plant problems.[67]

Another reason why the effect of an ideal thermal environment for schools needs to be measured is the growing use of school buildings during the summer months. Carroll and Bareither recognized the trend toward increased use of school buildings:

> The educational building of tomorrow must be designed for year round comfort conditioning. A fast-growing population of school age children and education-minded adults means that the physical plant will be open many more hours each day and continuously through summer months.[68]

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66 _____, "Current Study Probes Effects of Windowless Teaching," Audio-Visual Instruction, October 1962, p. 539.

67 Wilson, op. cit., p. C12.

68 J. Raymond Carroll and Harlan B. Bareither, "Comfort Conditioning for Educational Buildings," American School and University, 33rd edition, 1961-62, C1.

School systems that do have air conditioned buildings keep constructing them without the necessary research as to their educational value:

> The advantage of air conditioning is that it provides a better environment for the teaching-learning process. Communities that have experience with air conditioned schools keep building them.[69]

The value of providing controlled ideal thermal environments in school buildings should be for the students' benefit:

> Schools and colleges are places of learning. The first consideration of their plant design are the welfare of the occupants and improvement of their learning opportunities.[70]

A challenge has been given to those in education regarding the value of an ideal thermal environment:

> The challenge for education is to pile up evidence on the contribution air conditioning makes to an efficient learning environment, and then to guide architects and engineers toward the construction of air-conditioned buildings within approved budgets.[71]

There are at least two persons, Peña and Thomas,

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69 _____, "The Price of Better School Buildings," American School and University, 35th edition, 1963, pp. 47-50.

70 _____, "Air Conditioning and the Learning Environment," Overview, October, 1961, p. 50.

71 Ibid., p. 50.

who believe ideal thermal environment schools will not be built:

> Despite all its virtues, air conditioning will still be considered a "frill" by the American public and for many years to come. Apparently it is easier to put a man on the moon than to air condition all our schools.[72]

Summary

Many statements can be found in literature implying that a relationship does exist in the classroom between an ideal thermal environment and students' learning. However, the research in the area is too limited to base the relationship upon scientific evidence. Apparently judgements have been made wholly upon subjective and non-scientific evidence. This study does contribute to our knowledge concerning the effect of environment upon learning.

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72 William Peña and Joe B. Thomas, "Myths and Facts About Ventilation," American School and University, 35th edition, 1963, p. 42.

CHAPTER III

EXPERIMENTAL PROCEDURES AND CONDITIONS

Purpose of the Chapter

This chapter presents the experimental procedures and conditions that were followed during the course of the study.

Basic Procedure

Briefly the procedures followed in the study were as follows:

1. Twenty-two matched pairs of fifth grade pupils were selected from two classrooms.

2. A controlled thermal environment that was considered ideal was maintained in one classroom and in a second identical classroom a deviate thermal environment was maintained.

3. From each matched pair one student was placed in the controlled ideal thermal environment and the other student was placed in the deviate thermal environment.

4. The teaching of selected skills and subject areas was closely controlled. The instruction in the selected skills and subject areas was the same in both classrooms.

5. The students' achievement in the selected skills and subject areas was accurately measured.

6. Statistical tests were computed to measure student learning in the controlled ideal class-

room thermal environment as compared to student learning in a controlled deviate classroom thermal environment.

Time of Year

The study was conducted for eight weeks and four days, September 7, 1965, through November 5, 1965. Schools in Iowa traditionally begin the last week in August or the first week in September. Since the study was conducted during ordinarily warm Iowa school months, it was necessary to use mechanical cooling units in order to maintain the desired ideal thermal classroom environment.

The study began one week after the Saydel School District started their school year and extended for eight weeks and four days (approximately one-fourth of a school year). By conducting the study during this particular period, not only was it possible to maintain strict control over the desired learning tasks, but it was felt that the motivation level of the two groups was more nearly equal at this time than at any other time of the school year.

Students

The students that participated in the study were fifth grade students of the Saydel School District, Saydel,

Iowa. Fifth grade students were chosen for the experiment since (1) fourth grade students were used in the first study and sixth grade students were used in the second study, (2) the students were believed old enough to follow directions used in the various tests, (3) the researcher was interested in measuring pupil achievement in a concentrated period of handwriting lessons at this grade level, and (4) the availability of adequate programed science material for this particular grade.

Twenty-two matched pairs of students were selected for the study. The pairs of students in the two classrooms were matched on the following characteristics for this study:

1. Intelligence - based on the intelligence tests previously administered to the students.

2. Achievement - based on the results of the Iowa Test of Basic Skills. For matching purposes the overall composite score, the arithmetic composite score, and the spelling score of each pupil was used.

The results of the matching are summarized in Table II. This table lists the student number in column 1, the intelligence score in column 2, the overall composite score of the Iowa Test of Basic Skills in column 3, the arithmetic score on the test in column 4, column 5 has the students spelling score on the test, column 6 lists the age of the particular student, and the sex of the student is

TABLE II

GENERAL DATA FOR STUDENTS

GENERAL DATA FOR EXPERIMENTAL GROUP - GROUP A

Student	IQ	ITBS	Arith.	Spelling	Age	Sex	Father's Occupation
1	140	6.3	4.8	6.2	11	M	Painter
2	118	4.6	4.4	5.6	10	M	Rubber Worker
3	116	3.0	3.0	3.9	10	F	Factory
4	115	3.9	3.8	4.2	10	F	Unemployed
5	113	3.7	3.8	3.3	10	M	Bottler
6	110	4.0	2.7	6.6	10	F	Watchman
7	109	4.4	3.9	4.6	10	F	Heating
8	107	4.6	5.6	3.7	10	M	Disabled
9	105	2.8	2.8	1.5	10	M	Insurance
10	104	3.4	3.6	4.8	10	M	Welder
11	104	3.9	4.0	5.6	10	M	Mechanic
12	103	3.3	2.6	4.4	9	F	Service Station
13	100	2.7	3.1	2.6	10	M	Mechanic
14	100	3.7	4.0	3.1	10	M	Carpenter
15	99	2.7	3.2	2.6	9	F	Painter
16	99	3.4	3.9	2.6	10	F	Manufacturer
17	98	2.6	2.7	2.5	10	M	Mechanic
18	97	3.2	3.4	1.9	10	M	Truck Driver
19	91	4.3	4.0	4.4	10	M	Cab Driver
20	91	4.3	5.0	5.6	10	F	Painter
21	90	3.0	2.9	5.9	10	F	Loader
22	89	2.5	2.6	2.6	11	M	Telephone Company
Sum	2298	80.3	79.8	88.2	220		
Mean	104.5	3.65	3.63	4.01	10.0		
S.D.	11.34	.87	.81	1.45	.43	M -12, F - 10	

TABLE II (Cont'd)

GENERAL DATA FOR CONTROL GROUP - GROUP B

Student	IQ	ITBS	Arith.	Spelling	Age	Sex	Father's Occupation
1	132	6.0	4.4	5.6	10	M	Driver
2	127	3.3	3.4	3.7	10	M	Driver
3	125	3.0	4.0	2.4	11	M	Manufacturer
4	118	4.5	4.8	5.1	10	F	Carpenter
5	117	3.2	3.2	3.7	10	F	Rubber Worker
6	116	3.8	4.2	3.7	11	M	Factory
7	114	4.0	3.6	4.8	11	M	Disabled
8	109	4.5	3.6	5.3	10	M	Maintenance
9	107	4.9	4.8	7.1	10	F	Feed Worker
10	107	2.3	2.2	1.7	10	M	Rubber Worker
11	105	4.4	5.2	6.2	10	F	Manufacturer
12	105	3.5	3.5	3.3	11	M	Welder
13	105	4.2	4.6	3.3	10	M	Mechanic
14	105	3.1	3.7	2.9	10	F	Truck Driver
15	102	3.6	3.6	3.7	10	F	Truck Driver
16	97	3.4	3.5	4.0	10	F	Housewife
17	97	3.2	2.6	2.8	11	M	Cab Driver
18	97	4.1	3.4	5.3	10	F	Painter
19	97	3.7	3.4	4.8	10	F	Truck Driver
20	81	2.5	3.0	1.9	11	M	Truck Driver
21	77	2.7	2.9	3.3	11	M	Mechanic
22	75	2.3	2.6	2.9	11	F	Truck Driver
Sum	2315	80.2	80.2	87.5	228		
Mean	105.2	3.65	3.65	3.98	10.4		
S.D.	14.58	.88	.76	1.36	.48	M - 12, F - 10	

listed in column 7. The remaining column in Table II contains information about each guardian's occupation.

Also shown in Table II are the means and standard deviations of each of the characteristics on which the students were matched. The mean intelligence quotient score for Group A was 104.5 and for Group B the mean was 105.2. Group A has a mean composite score on the Iowa Test of Basic Skills of 3.65. The mean on this test for Group B was also 3.65. Group A's mean on the Arithmetic Composite Score on the Iowa Test of Basic Skills was 3.63 and Group B's mean on the test was 3.65. The remaining score used for matching purposes was the spelling score on the Iowa Test of Basic Skills. On the spelling score of the test, the mean of Group A was 4.01 while Group B had a mean of 3.98 on the spelling section of the Iowa Test.

Both Groups A and B were subdivided into two levels. These two levels were (1) a high ability level and (2) a low ability level. The students in the two Groups had been matched on the previously cited criteria; e.g., Intelligent Quotient Scores and Iowa Test of Basic Skills Scores. Students having the identification numbers one through eleven were placed in the high ability level group and those students having the identification numbers twelve

through twenty-two were placed in the low ability level group.

Selected statistics were computed following the placement of the students into the two levels; the groups were called the high ability level groups and the low ability level groups. The results of these computations are reported in Table III.

From Table III it can be seen that the mean intelligence score for the high ability level groups was 114.5 and for the low ability level groups the mean intelligence quotient score was 95.2. The mean composite score on the Iowa Test of Basic Skills was 4.02 for the high ability level groups and 3.27 for the low ability level groups. The high ability level groups had a mean score of 3.90 on the arithmetic composite score of the Iowa Test of Basic Skills and 3.37 was the mean for the low ability level groups. On the spelling score of the test the mean of the high ability level groups was 4.51 while the low level ability groups had a mean of 3.47 on the spelling section of the Iowa Test of Basic Skills.

Classrooms

Through the courtesy and cooperation of the Lennox Industries Inc. a Research School was made available for

TABLE III

GENERAL DATA FOR ABILITY LEVELS
GENERAL DATA FOR THE HIGH ABILITY LEVEL GROUPS
(Identification Numbers One through Eleven)

Experimental Group - Group A

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1241	44.6	42.4	50.0	111	
Mean	112.8	4.05	3.85	4.54	10.1	M=6
S.D.	9.79	.92	.83	1.39	.29	F=5

Control Group - Group B

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1277	43.9	43.4	49.3	113	
Mean	116.1	3.99	3.94	4.48	10.3	M=7
S.D.	8.52	.98	.82	1.54	.44	F=4

Combination of High Ability Level Groups

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	2518	88.5	85.8	99.3	224	
Mean	114.5	4.02	3.90	4.51	10.2	M=13
S.D.	9.32	.94	.83	1.47	.39	F=9

TABLE III (con'd)

GENERAL DATA FOR THE LOW ABILITY LEVEL GROUPS
(Identification Numbers Twelve through Twenty-Two)

Experimental Group - Group A

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1057	35.7	37.4	38.2	109	
Mean	96.1	3.24	3.40	3.47	9.9	M=6
S.D.	4.66	.61	.72	1.30	.51	F=5

Control Group - Group B

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	1038	36.3	36.8	38.2	115	
Mean	94.4	3.30	3.34	3.47	10.5	M=5
S.D.	10.79	.59	.54	.91	.50	F=6

Combination of Low Ability Level Group

	IQ	ITBS	Arithmetic	Spelling	Age	
Sum	2095	72.0	74.2	76.4	224	
Mean	95.2	3.27	3.37	3.47	10.2	M=11
S.D.	8.36	.60	.64	1.12	.57	F=11

this study. This Research School located in Des Moines, Iowa, is for the specific purpose of finding new, improved and economical methods of providing different thermal classroom environment.

The floor plan of the school is shown in Figure 1.

The school has two classrooms. Each classroom has exactly the same square feet area (930 square feet). Both rooms are identical with one exception; one classroom's floor to ceiling height is eighteen inches greater than the other room. In the two previous studies carried out by the State University of Iowa the differences in floor to ceiling distance had no effect on pupil achievement and consequently both classrooms could be treated as though they were identical.

As previously stated, the school was not built for the specific purpose of carrying on regular classroom education. However, the school was designed by the architectural firm of Perkins and Wills of Chicago, Illinois. Both classrooms were so designed that each classroom was self-contained in all respects. Each room has its own book shelves. Located at the rear of each classroom is a pupil restroom.

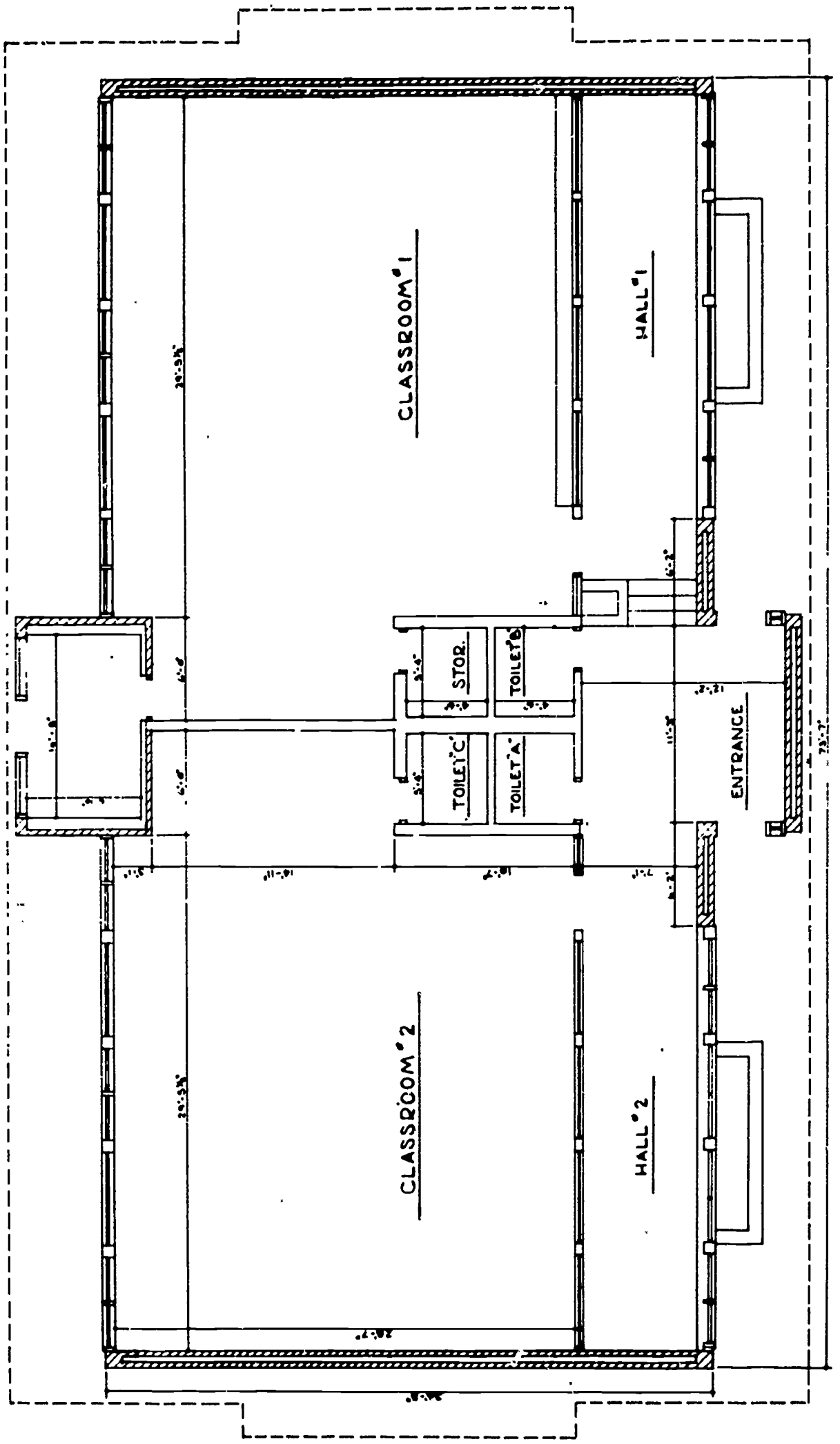

Figure 1

FLOOR PLAN OF THE LENNOX RESEARCH SCHOOL

Also located at the rear of each classroom is the necessary mechanical equipment that is used to maintain the desired thermal conditions in either of the two classrooms. In addition this area contains the necessary instruments for measuring and recording the thermal environment of each classroom.

For the sake of completeness, the "U" Factors of the school house are reported: Ceiling and Roof .13; Exposed Glass 1.13; Exposed Walls .30; Floor East Room .95; Floor West Room 1.90. The "U" Factor is simply a measurement of the rate of heat loss in a building. The "U" Factors of the Research School are quite normal for school house construction in Iowa.

Lunch was served by a private catering service; however, the students that participated in this study paid the same price for their lunch as other Saydel students eating the lunch served by the Saydel School District. Each of the two groups of students involved in this study were served lunch in the hall at the Research School and brought the food back to their own classroom for eating.

Thermal Conditions

The mechanical units in the Research School were

capable of maintaining the desired classroom thermal environment. For this study one classroom had a controlled thermal environment that was considered as ideal. In the second classroom a deviate thermal environment was maintained. At no time during the study was the thermal environment in the deviate thermal classroom the same as that in the controlled ideal thermal environment.

Using the experience gained in the first two experiments and after an extensive review of the literature, the following thermal environment was maintained in the Ideal Classroom:

1. Temperature in the range of 70°F. to 74°F. The mechanical equipment in each classroom maintained temperature to within a plus or minus one degree of the desired temperature.
2. Humidity was kept between 40 and 65 per cent.
3. Air movement was in the range of 20 to 40 fpm.
4. All classroom air was filtered through a blanket-type fiberglass filter.

Allowable temperature limits of 70°F. to 74°F. were established in the Ideal Classroom; the lower end of this range was considered optimum for the heating season and the upper range was considered optimum for the cooling season. The difference between optimum winter and summer temperatures was based on the results of a study conducted by the

American Society of Heating and Air-Conditioning Engineers. This study indicated that occupants were comfortable at a higher temperature in summer than in winter.

The thermal conditions of a classroom in the students' regular home school were also recorded every hour of the day during the study. This classroom was chosen since its location corresponded to the regular home classroom of the students who were in the deviate thermal classroom for this study. The thermal conditions of the "home" classroom are reported in Appendix L.

The following thermal environment was maintained in the deviate classroom:

1. Temperature was kept at a minimum of 70°F.
2. Humidity was allowed to fluctuate as in a typical classroom.
3. Air movement, when heating was required, was in the range of 20 to 40 f.p.m.
4. The teacher of the deviate classroom was free to open windows, turn on fans, or open doors as she might in her regular home classroom.

Thermal Measurement Instruments

Several instruments were used to measure the thermal data used in the study. All the measuring instruments that were used are known to be highly accurate in

measuring air temperature, relative humidity and air movement. A Research Engineer employed by Lennox Industries Inc. was assigned to the study. He carried out all the thermal tests and maintained the thermal conditions used in this study.

Two Taylor mercurial thermometers having a range of 20°F. to 120°F. were used as calibration instruments.

A 12 point Type 153 Electronik Recorder, Model No. 153X72P12-X-26 with type J thermocouples was used to provide a continuous printed record of temperatures, dry bulb and wet bulb readings. This recorder was capable of recording thermocouple readings from -50°F. to 200°F. This recorder was calibrated to an accuracy of one-half of one degree. The recorder printed the thermocouple readings in multicolor in a cycle of one reading every five seconds. The chart speed was 24 inches per hour. Recorded on the chart were four air temperature readings at the student's desk level; one temperature reading was taken in each quadrant of the classrooms. Also recorded on the chart was a dry and wet bulb reading of the mechanical psychrometer. For every minute between 0800 hours and 1600 hours the chart had 12 readings, six for each room.

To insure the accuracy of the thermocouple readings, the Research Engineer checked the recorder two times each day with the Taylor mercurial thermometer.

The mechanical psychrometer used to measure humidity at the student desk level had a standard wick and gave wet and dry bulb readings. One mechanical psychrometer was located in each classroom. The accuracy of the mechanical psychrometers was checked twice each day with a sling psychrometer.

A vane-type anemometer was used to measure the velocity of the air discharged into the classrooms by the mechanical equipment. The air movement at student desk level was measured with an Anemotherm-Model 60 hot wire anemometer. This is a thermal-type anemometer and gives a direct reading of temperature, velocity and static pressure. It has an accuracy that is acceptable for most laboratory work.

In the students' homeroom at the Norwoodville Schools a Brown Instruments Thermo Humidigraph was the instrument used to record temperature and humidity continuously on a 24 hour chart. This was a Model 612X21KL-X-86 instrument manufactured by the Brown Instruments Division of Minneapolis-Honeywell Regulator Company. This instru-

ment was capable of recording temperatures from 0°F. to 100°F. and of relative humidity from 0 to 100%.

A thermal condition of the Research School was recorded every five seconds of the day during the study from 0800 hours through 1600 hours. These recordings were of the thermal conditions in the ideal thermal environment classroom and in the deviate thermal environment classroom. The actual thermal conditions maintained throughout the study in both the controlled ideal classroom and the deviate classroom as well as the outside temperature and humidity are reported in Table IV for the hours 0900 through 1500.

Each day during the study the mean temperature was computed for the ideal thermal environment classroom, the deviate thermal environment classroom, and the outside temperature. For this computation the readings reported in Table IV were used. The results of these computations are shown in Figure 2.

Selection of the Control and Experimental Groups

The matched groups were placed in the control and the experimental group by a flip of a coin. Using this procedure, Group A students were placed in the experimental classroom and Group B students were placed in the controlled

TABLE IV

[illegible] QUALITY DISCRIMINATION
IDEAL CLASSIFIER, DEVIATE CLASSIFIER, OUTSIDE

Date	Type	900		1000		1100		1200		1300		1400	
										P	R	P	R
Sept. 7	Ideal	[illegible]		[illegible]		[illegible]		77	61	76	77	74	73
	Deviate	77	79	[illegible]		[illegible]		81	79	78	76	80	78
	Outside	68	100	65	100	[illegible]	100	67	100	64	100	66	97
Sept. 8	Ideal	73	71	72	[illegible]	[illegible]	74	[illegible]	74	72	74	73	71
	Deviate	77	71	71	7	[illegible]	74	[illegible]	71	81	75	81	75
	Outside	61	[illegible]	61	[illegible]	73	[illegible]	67	67	69	97	71	97
Sept. 9	Ideal	74	79	74	[illegible]	74	64	71	67	75	67	76	64
	Deviate	71	61	64	[illegible]	61	68	61	64	69	64	69	71
	Outside	77	92	81	77	95	[illegible]	67	64	64	61	83	61
Sept.10	Ideal	71	56	72	[illegible]	75	48	72	[illegible]	72	60	72	54
	Deviate	79	[illegible]	68	86	81	52	62	62	60	59	80	54
	Outside	55	60	58	77	80	74	[illegible]	63	65	68	67	61
Sept.13	Ideal	73	74	74	75	74	[illegible]	[illegible]	[illegible]	73	70	73	61
	Deviate	79	70	81	[illegible]	[illegible]	68	[illegible]	72	68	71	83	60
	Outside	68	100	65	87	71	68	72	[illegible]	72	87	73	87
Sept.14	Ideal	71	74	73	74	74	74	71	74	73	61	74	61
	Deviate	74	61	81	62	81	68	[illegible]	[illegible]	[illegible]	69	83	69
	Outside	65	100	68	100	69	100	[illegible]	87	69	87	69	93
Sept.15	Ideal	74	54	74	56	74	[illegible]	70	[illegible]	73	54	73	61
	Deviate	77	59	68	47	[illegible]	68	[illegible]	68	80	47	81	[illegible]
	Outside	63	86	55	77	68	77	67	75	58	72	59	86
Sept.16	Ideal	72	57	75	62	74	61	70	61	74	56	72	61
		80	40	70	54	70	61	70	61	68	61	80	68
		65	100	54	100	55	100	60	100	57	100	59	100
Sept.17	Ideal	71	53	73	51	73	57	73	58	73	68	73	51
	Deviate	77	64	79	71	80	57	80	62	80	61	81	62
		57	100	57	86	59	96	63	90	62	90	63	87

[illegible]

[illegible] CLASSROOM, [illegible] CLASSROOM, OUTSIDE

[illegible]	0900 T	0900 H	1000 T	1000 H	1100 T	1100 H	1200 T	1200 H	1300 T	1300 H	1400 T	1400 H	1500 T	1500 H	Total T
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	75	74	70	75	74	[illegible]
Deviate	77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	78	75	80	75	75	73	79.
Outside	68	[illegible]	[illegible]	[illegible]	[illegible]	100	87	[illegible]	[illegible]	100	66	97	66	90	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	74	73	70	73	[illegible]	[illegible]
Deviate	77	[illegible]	[illegible]	[illegible]	[illegible]	74	[illegible]	71	81	75	81	79	80	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	67	67	69	97	71	94	72	94	[illegible]
Ideal	[illegible]	[illegible]	74	[illegible]	[illegible]	[illegible]	75	67	75	67	76	64	75	63	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64	89	64	89	70	89	60	[illegible]
Outside	77	92	[illegible]	77	[illegible]	[illegible]	87	94	[illegible]	61	88	81	87	66	[illegible]
Ideal	71	[illegible]	72	[illegible]	73	48	72	[illegible]	72	50	72	54	74	[illegible]	72.5
Deviate	79	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52	80	50	80	54	82	54	80.5
Outside	55	[illegible]	50	77	[illegible]	70	[illegible]	[illegible]	65	63	67	61	67	[illegible]	[illegible]
Ideal	73	74	74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	70	73	65	74	[illegible]	[illegible]
Deviate	[illegible]	73	81	[illegible]	[illegible]	[illegible]	[illegible]	72	82	71	83	66	[illegible]	[illegible]	[illegible]
Outside	63	100	[illegible]	[illegible]	71	[illegible]	72	[illegible]	72	87	73	87	75	84	[illegible]
Ideal	71	74	73	74	[illegible]	[illegible]	[illegible]	[illegible]	73	61	74	56	73	[illegible]	[illegible]
Deviate	[illegible]	81	81	[illegible]	81	[illegible]	[illegible]	[illegible]	[illegible]	69	83	68	82	[illegible]	[illegible]
Outside	[illegible]	100	66	100	[illegible]	100	[illegible]	87	[illegible]	97	69	93	[illegible]	[illegible]	[illegible]
Ideal	74	64	74	65	74	[illegible]	70	[illegible]	73	54	73	51	73	64	[illegible]
Deviate	77	[illegible]	[illegible]	47	[illegible]	[illegible]	[illegible]	50	80	47	81	44	80	40	[illegible]
Outside	63	83	55	77	[illegible]	77	57	75	59	72	59	69	59	79	56.8
Ideal	72	57	75	62	74	61	73	61	74	56	72	56	72	53	73.1
	80	40	79	34	79	61	79	61	80	61	80	58	80	64	79.5
	[illegible]	100	54	100	55	100	56	100	57	100	59	100	62	97	56.5
Ideal	71	53	73	[illegible]	73	57	73	58	73	65	73	57	72	57	72.5
Deviate	77	54	79	[illegible]	80	57	80	62	80	61	81	62	81	55	79.7
	57	100	57	56	59	98	63	90	62	93	63	87	61	90	60.2

TABLE IV (Continued)

Date	Place	0900 T		1000 T		1100 T		1200 T		1300 T		1400 T	
Sept.20	Ideal	72	77	71		71		71		72		71	
	Deviate	79	81	81		76						75	
	Outside	83	100	83	100		100	83	100	83	87	83	
Sept.21	Ideal	73	81	71		71		72		71	77	73	
	Deviate	83	77			71		73				83	
	Outside	83	83	83		71				87		83	
Sept.22	Ideal	73		73		73		73		72	77	71	
	Deviate	71		83		83		71				82	
	Outside	87	81	83		83		87		83	83	83	
Sept.23	Ideal	72	81	73	71	73		73		73	83	72	
	Deviate	80	81	81	83	73		77				71	
	Outside	46	83	42	83	47		47			83	82	
Sept. 24	Ideal	72	35	71		72		72		71		73	
	Deviate	70	46	79							87	80	
	Outside	46	71	46	73	44				79	82	84	
Sept.27	Ideal	73		73		73		73		73		72	
	Deviate	73		81								78	
	Outside		81	46		47		47			100	46	
Sept.28	Ideal	71	81	73		73		73		73		73	
	Deviate											82	
	Outside	83	87	83		73		73		73	92	75	
Sept.29	Ideal	73		73		74		73		73		73	
	Deviate	83										84	
	Outside	83	81	83		73		73		73	77	75	
Sept.30	Ideal	71	69	72		73		73		73		73	
	Deviate	79		79		83		83				81	
	Outside	49	83	53		49		47		73	77	81	
Oct. 1	Ideal	74		73		73		73		73		73	
	Deviate	80		83		83						81	
	Outside	51	74	55		53		45			87	67	

TABLE IV (Continued)

Place	0900		1000		Time 1100		1200		1300		1400		1500		Ave. Total
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	
Ideal	72	77	75		71	4	79	1	78	14	71	58	75	58	71.7
Deviate	79	61	91	4	7	1	4	1	14	42	75	67	10	67	71.2
Outside	68	100	68	100	1	100	68	100	78	67	63	67	84	68	71.3
Ideal	78	81	74	1	7	81	78	1	78	57	78	64	7	81	7 .3
Deviate	68	7	1	1	11	12	68	1	11	44	60	57	80	84	7 .4
Outside	68	68	61	81	81	81	1	84	84	68	58	68	68	71	68.9
Ideal	78	1	7	81	71	84	7	17	77	78	71	68	78	81	71.1
Deviate	71	1	81	1	68	84	81	81	1	1	62	68	81	84	71.6
Outside	67	81	68	71	68	68	67	81	68	68	68	68	68	68	71.4
Ideal	72	58	74	58	72	58	74	58	78	58	72	68	72	68	72.4
Deviate	80	81	81	42	71	8	71	4	1	1	71	42	78	42	75.2
Outside	48	68	48	68	47	84	47	8	81	68	52	68	62	84	61.5
Ideal	72	38	72	84	72	38	72	81	71	68	78	38	78	40	71.1
Deviate	78	48	78	47	1	41	68	47	1	47	80	42	68	42	71.8
Outside	48	71	48	78	48	68	78	81	82	61	84	57	88	88	71.8
Ideal	78	48	78	81	78	48	78	8	78	88	72	88	72	88	72.4
Deviate	78	84	81	1	8	17	81	84	1	88	78	58	81	58	78.1
Outside	48	91	48	88	47	88	48	100	1	100	48	88	88	88	67.8
Ideal	71	88	73	8	71	88	78	8	78	84	78	81	78	84	78.8
Deviate	81	84	81	1	81	8	84	82	81	82	82	84	88	82	81.7
Outside	88	87	88	71	78	88	71	88	84	82	75	82	75	84	78.1
Ideal	78	88	78	88	74	88	78	88	78	71	78	84	78	88	78.1
Deviate	88	74	81	84	87	84	88	88	84	81	84	88	88	88	82.7
Outside	88	81	88	78	71	71	78	88	78	78	75	82	78	88	72.1
Ideal	71	50	72	58	72	47	72	47	78	47	78	47	78	47	72.2
Deviate	78	54	78	50	82	43	81	47	82	47	81	54	81	58	80.5
Outside	49	83	58	93	49	77	58	78	68	78	61	77	58	69	68.1
Ideal	74	44	73	84	71	41	73	44	72	40	73	40	73	40	73.1
Deviate	80	47	80	47	82	46	81	44	84	44	81	42	81	44	80.7
Outside	51	74	55	84	88	58	84	45	88	38	67	37	68	38	61.5

TABLE IV (Continued)

Date	Place	0900		1000		1100		1200		1300		1400	
		T.	H.	T.	H.	T.	H.	T.	H.	T.	H.	T.	H.
Oct. 4	Ideal	72	39	7[illegible]	[illegible]7	[illegible]	[illegible]	74	[illegible]	73	[illegible]0	73	[illegible]
	Deviate	77	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	80	[illegible]
	Outside	80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	66	49	66	[illegible]
Oct. 5	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74	[illegible]7	70	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]2	[illegible]8	82	[illegible]
	Outside	55	[illegible]	5[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	53	69	[illegible]
Oct. 6	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	47	70	[illegible]
	Deviate		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	81	52	81	[illegible]
	Outside		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	69	59	71	[illegible]
Oct. 7	Ideal		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		73	38	73	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	[illegible]	79	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87	28	80	[illegible]
Oct. 8	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	38	72	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82	38	81	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	83	37	85	[illegible]
Oct.11	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.12	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	[illegible]	73	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	[illegible]	[illegible]	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.13	Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.14	Ideal	72	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.15	Ideal	72	57	73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]
	Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Outside	[illegible]	93	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE IV (Continued)

Place	0900 T	0900 H	1000 T	1000 H	Time 1100 T	1100 H	1200 T	1200 H	1300 T	1300 H	1400 T	1400 H	1500 T	1500 H	Mean Temp
Ideal	72	39	74	37	[illegible]	[illegible]	74	[illegible]	73	[illegible]	73	[illegible]	73	[illegible]	73.1
Deviate	77	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74	[illegible]	73	[illegible]	[illegible]	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	47	73	51	73	54	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	69	59	71	44	72	34	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	35	72	35	[illegible]	33	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	26	66	32	65	34	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	36	72	38	73	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63	37	65	33	[illegible]	[illegible]	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	74	35	73	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	[illegible]	73	[illegible]	[illegible]	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	72	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]	[illegible]	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ideal	72	57	73	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]	[illegible]	[illegible]	[illegible]
Deviate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Outside	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE IV (Continued)

Date	Place	Time 0900 T	H	1000 T	H	1100 T	H	1200 T	H	1300 T	H	1400 T	H
Oct.18	Ideal	71	60	73	59	73	51	73	51	73	52	73	[illegible]
	Deviate	77	61	80	58	82	55	83	53	83	55	84	[illegible]
	Outside	67	70	72	59	76	52	76	47	80	42	80	[illegible]
Oct.19	Ideal	73	56	72	57	73	58	74	56	73	54	73	[illegible]
	Deviate	78	58	81	55	80	57	82	55	81	53	82	[illegible]
	Outside	66	76	68	73	68	73	68	73	66	81	65	[illegible]
Oct.20	Ideal	72	54	73	51	72	54	72	54	72	54	72	[illegible]
	Deviate	77	54	79	51	78	52	80	50	80	54	81	[illegible]
	Outside	58	83	56	77	57	75	57	75	56	80	54	[illegible]
Oct.21	Ideal	71	53	73	51	73	50	73	51	73	50	73	[illegible]
	Deviate	77	52	79	47	79	49	81	47	80	47	79	[illegible]
	Outside	50	86	48	89	49	93	51	90	52	71	53	[illegible]
Oct.25	Ideal	73	37	72	43	73	46	73	47	73	47	73	[illegible]
	Deviate	79	31	80	35	81	38	80	40	81	41	82	[illegible]
	Outside	52	59	55	55	60	49	62	50	65	47	68	[illegible]
Oct.26	Ideal	71	41	73	47	73	43	73	43	73	47	71	[illegible]
	Deviate	78	30	80	35	79	35	80	40	80	35	80	[illegible]
	Outside	46	68	50	61	58	51	57	45	58	40	60	[illegible]
Oct.27	Ideal	72	41	74	44	74	47	73	51	73	50	74	[illegible]
	Deviate	78	35	80	38	79	42	80	41	81	35	82	[illegible]
	Outside	49	61	53	54	50	51	60	44	63	38	65	[illegible]
Oct.28	Ideal	71	60	73	47	73	47	72	44	73	44	71	[illegible]
	Deviate	76	41	78	41	79	40	79	47	79	43	79	[illegible]
	Outside	42	62	46	55	49	50	52	43	53	39	56	[illegible]
Oct.29	Ideal	72	34	72	50	73	47	74	47	73	50	72	[illegible]
	Deviate	82	39	78	33	79	37	79	40	81	40	81	[illegible]
	Outside	46	49	50	46	56	43	59	42	62	42	65	[illegible]
Nov. 1	Ideal	71	38	73	47	74	44	73	44	71	45	71	[illegible]
	Deviate	78	30	79	31	81	33	81	38	80	35	80	[illegible]
	Outside	42	70	51	54	56	43	59	36	61	31	62	[illegible]

TABLE IV (Continued)

Place	Time 0900 T	0900 H	1000 T	1000 H	1100 T	1100 H	1200 T	1200 H	1300 T	1300 H	1400 T	1400 H	1500 T	1500 H	Mean Temp.
Ideal	71	60	73	58	76	51	73	51	73	51	73	51	72	50	72.3
Deviate	77	61	80	56	82	55	83	53	85	55	84	52	83	52	80.7
Outside	67	70	72	59	76	52	78	47	80	42	80	42	80	41	71.1
Ideal	73	56	72	57	73	59	74	59	73	54	73	58	73	58	73.1
Deviate	78	58	81	55	80	57	82	55	81	53	82	52	82	55	80.0
Outside	65	76	68	73	68	73	68	73	66	81	65	87	65	84	88.8
Ideal	72	54	73	51	72	54	72	54	72	54	72	54	72	57	72.1
Deviate	77	54	79	51	78	52	80	50	80	54	81	50	80	54	74.2
Outside	55	83	56	77	57	75	57	75	56	80	54	80	53	80	88.8
Ideal	71	53	73	51	73	50	73	51	73	50	73	47	73	43	72.7
Deviate	77	52	79	47	79	49	81	47	80	47	79	46	79	47	74.1
Outside	50	86	48	89	49	93	51	90	52	71	53	69	54	61	81.0
Ideal	73	37	72	43	73	46	73	47	73	47	73	44	72	42	72.1
Deviate	79	31	80	35	82	38	83	43	81	41	82	36	80	39	70.
Outside	52	59	55	55	60	49	69	50	65	47	68	39	69	37	71.4
Ideal	71	41	73	47	73	48	73	48	73	47	71	45	73	47	72.1
Deviate	78	30	80	35	79	36	83	40	80	35	80	32	83	34	79.3
Outside	46	68	50	61	56	51	57	48	58	48	60	39	58	38	68.1
Ideal	72	41	74	44	74	47	73	51	73	50	74	51	72	50	73.1
Deviate	78	35	80	38	79	42	80	41	81	35	82	30	78	37	76.7
Outside	49	61	53	54	50	51	60	44	63	38	65	38	64	38	68.5
Ideal	71	60	73	47	73	47	73	44	73	44	71	45	72	46	72.3
Deviate	76	41	78	41	79	40	79	47	79	43	79	39	80	38	74.0
Outside	42	62	46	55	49	50	52	43	53	39	53	38	54	38	48.8
Ideal	72	34	72	50	73	47	74	47	73	50	72	51	71	48	72.4
Deviate	82	38	78	33	79	37	79	40	81	40	81	39	82	39	80.2
Outside	46	49	50	46	58	43	59	42	62	42	65	41	65	43	57.4
Ideal	71	38	73	47	74	44	73	44	71	45	71	45	72	43	72.1
Deviate	78	30	79	31	81	33	81	38	80	35	80	32	80	32	76.8
Outside	42	70	51	54	56	43	60	36	61	31	62	30	62	30	56.1

TABLE IV (Continued)

Date	Place	Time 0900 T	0900 H	1000 T	1000 H	1100 T	1100 H	1200 T	1200 H	1300 T	1300 H	1400 T	1400 H
Nov. 2	Ideal	71	56	74	44	73	47	72	48	72	48	72	47
	Deviate	77	39	80	41	81	42	80	39	80	39	84	38
	Outside	58	62	63	56	66	50	71	42	73	41	75	37
Nov. 3	Ideal	72	48	74	44	73	47	72	48	73	50	72	47
	Deviate	78	37	80	35	82	39	81	38	81	41	81	38
	Outside	62	54	62	54	66	47	66	47	70	46	67	47
Nov. 4	Ideal	71	38	74	54	73	46	73	44	73	47	73	47
	Deviate	78	30	79	37	78	34	80	37	81	35	79	36
	Outside	57	73	41	65	44	58	47	51	53	48	52	48
Nov. 5	Ideal	72	30	74	44	75	47	79	51	73	50	71	47
	Deviate	78	29	79	29	78	34	80	40	80	39	81	36
	Outside	48	80	53	77	62	67	66	60	66	65	67	65

TABLE IV (Continued)

Place	Time 0900 T		1000 T		1100 T		1200 T		1300 T		1400 T		1500 T		1600 T	
Ideal	71	56	74	54	73	47	72	53	71	53	72	54	73	[illegible]	73.[illegible]	
Deviate	77	36	80	41	81	42	80	39	83	39	84	35	83	38	81.4	
Outside	58	32	63	56	66	50	71	42	73	41	75	38	76	34	[illegible].6	
Ideal	72	48	74	54	73	47	72	4[illegible]	73	50	72	47	71	40	72.4	
Deviate	78	37	80	35	82	39	81	38	81	41	81	38	81	41	80.5	
Outside	62	54	62	54	66	47	67	47	65	48	67	47	68	44	65.2	
Ideal	71	38	74	54	73	40	73	44	73	47	73	47	71	51	72.6	
Deviate	77	30	79	37	78	34	80	37	81	35	79	30	80	32	79.4	
Outside	57	73	41	65	44	58	47	51	50	48	52	48	52	46	48.1	
Ideal	72	38	74	44	75	47	72	50	73	50	72	49	71	51	72.4	
Deviate	78	29	79	29	78	34	80	40	80	39	81	38	80	43	79.2	
Outside	48	80	53	77	62	67	66	60	66	65	67	65	67	63	61.1	

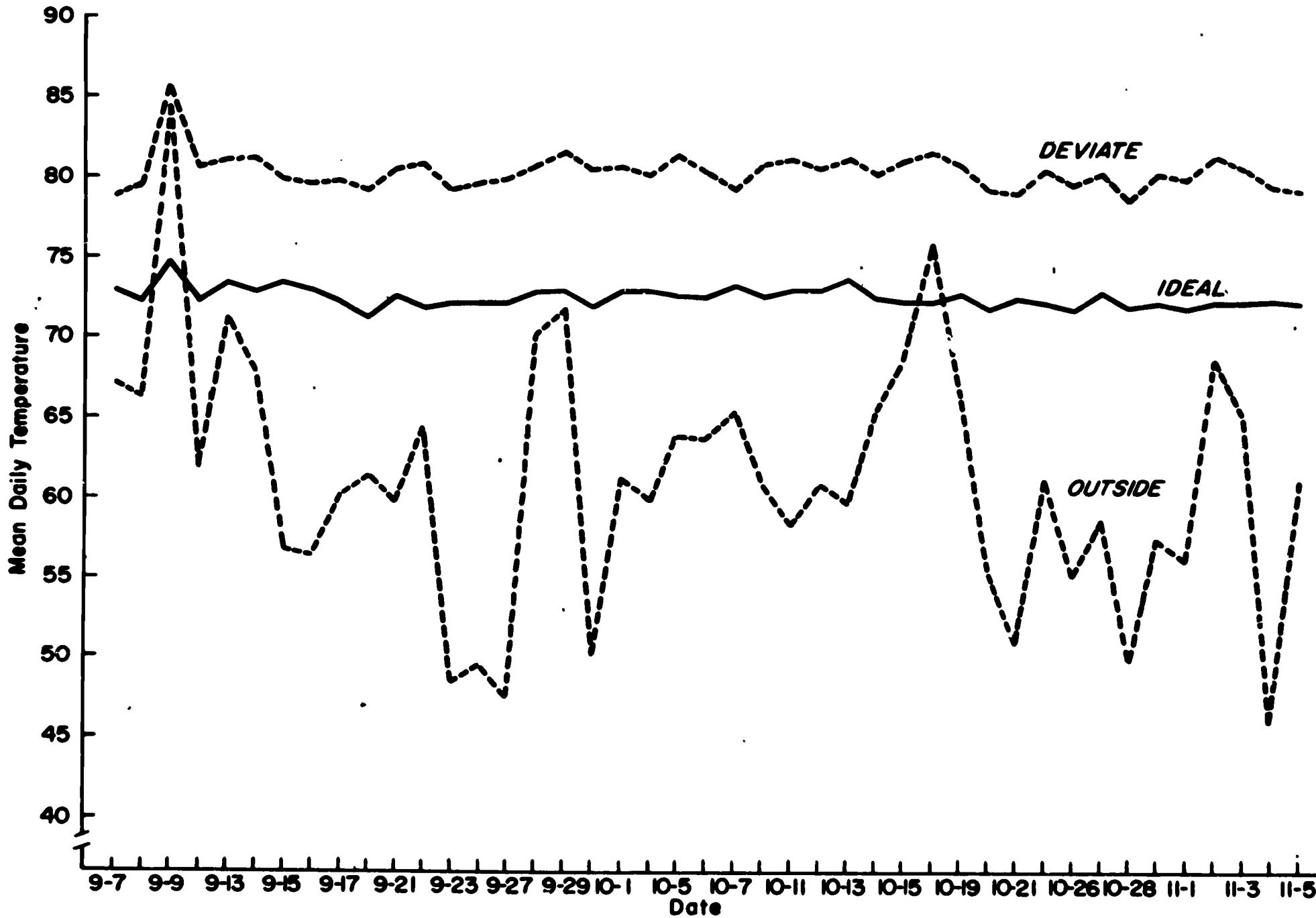

Figure 2

MEAN TEMPERATURE - IDEAL CLASSROOM, DEVIATE CLASSROOM, OUTSIDE

classroom. The experimental group was placed in the classroom that had the controlled ideal thermal environment and the control group was placed in the classroom that had the deviate thermal environment.

Skills and Subject Areas

The specific learning skills and subject areas measured for this study were:

1. Spelling
2. Handwriting
3. Accuracy on an adding machine
4. Mathematics problems
5. Science

Four of these skills were selected as they involved regular elementary school subjects. Spelling, handwriting, mathematics and science are offered in nearly every elementary school. Accuracy on an adding machine was included as it approximates typewriting as a subject.

These five skills and subject areas were also selected as they involved a variety of learning aptitudes.

In addition to selecting the skills and subject areas for the above reasons, they were selected because student achievement in each area could be objectively

measured.

The skills and subject areas were taught by an Iowa certified elementary teacher. The teacher and her role in the study is explained in greater detail later in this chapter. All skills and subject areas measured for this study were taught by the same teacher and presented to each class in as identical a method as humanly possible. At all times the skills and subject areas were presented to both the control group and the experimental group using an accepted teaching method. The skills and subject areas were presented as follows:

Spelling - The method used to teach and to test spelling achievement was the method currently used at the State University of Iowa's Elementary School. Using this method the students were given spelling lessons Monday, Wednesday and Friday. Each Monday the students were presented twenty new spelling words. A review of the words was given on Wednesday. On Friday the students took a test over the spelling words. This Friday test score was used for measuring spelling achievement.

In order to insure control of instructional methods in both classes, all spelling instructions to the students were given via a tape recorder.

The spelling words used in the study were taken from The New Iowa Spelling Scale.[1] The words chosen were between the 35 percent to 50 percent level of difficulty for the fifth grade. After the words were chosen they were placed in groups of twenty for each lesson by means of a table of random numbers. In order to insure the clarity of the tape recordings, to test the word list, and the validity of the method of instruction the first three weeks lessons were first used in the State University of Iowa's Elementary School in the spring of 1965. These tests were conducted with fourth grade pupils.

A week by week spelling list of the words used in this study is presented in Appendix B of this report.

Handwriting - The handwriting system used for this study was the Zaner-Blozer system. This system was chosen since it was the method in which the students had previously received instruction in the Saydel School. Handwriting was taught twenty minutes daily during a four week period of the study, September 13 through October 8. Using the Friday handwriting work, each student was given a handwriting score. All handwriting was evaluated using Feldt's

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[1] Harry A. Greene, The New Iowa Spelling Scale, State University of Iowa, 1954.

suggestions as stated in "The Reliability of Measures of Handwriting Quality."[2]

A copy of the handwriting materials used in the study is presented in Appendix C of this report.

Accuracy - Accuracy was measured through the use of ten-key adding machines. The machines used for this study were hand operated Monroe ten-key adding machines. A representative from the Monroe Company gave an oral demonstration lesson on the proper use of the ten-key adding machine to both the control group and the experimental group.

Arithmetic problems were given to the students on teacher prepared work sheets using the ten-key adding machine. By using the adding machines it was possible to compare the students' accuracy in punching keys by comparing each student's adding machine tape with the problem on the worksheet.

Students worked on this accuracy skill two periods a week, Tuesday and Thursday, for exactly fifteen minutes each period during the course of the study. For measuring purposes, the first lesson of each week was considered a

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2 Leonard S. Feldt, "The Reliability of Measures of Handwriting," Journal of Educational Psychology, Vol. 53, No. 6, 1962, pp. 288-292.

practice lesson and the second lesson was scored for errors.

A copy of the worksheets used in measuring students' accuracy is presented in Appendix D of this report.

Mathematics - For the purpose of this study students' skill in mathematics was measured by working arithmetic problems. Arithmetic problems of the type usually used for student drill were used.

The problems were presented to the students on individual worksheets. The students simply worked the problems and wrote their answers on the worksheet. The students worked on these mathematical skills three periods a week for exactly fifteen minutes each period. The days chosen for this subject were Monday, Wednesday and Friday. The student's score was computed by counting the number of correct answers on the Friday worksheet.

A copy of the worksheets used for measuring students skills in mathematics is presented in Appendix E of this report.

Science - All science used in this study was taught by units using programed learning materials. The programed materials used were produced by Cornet Learning Films and were the units "How Scientists Think and Work"[3] and "Your

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[3] _____, The Way a Scientist Thinks, Cornet Instructional Films, Chicago 1, Illinois, 1964.

Heart and Circulatory System."[4] The students were permitted to answer the programed materials by writing the correct answer in the blank provided.

Although a time limit was not rigidly fixed because of the nature of the programed materials, approximately twenty-five minutes was spent three times a week on the programed science materials. The students used their science programed materials on Monday, Wednesday and Friday. Each student's score was derived by counting the number of correct responses on the Friday lesson.

It was noticed both by the regular classroom teachers and by the special teacher that some of the students would look ahead at the answers in the programed book before filling in the blank. In order to insure this could not be done, the Friday lesson was given to the students on a mimeographed copy of the lesson.

Teachers

Regular classroom teachers employed by the Saydel Schools were used to teach the regular classroom program. The skills and subject areas used in this study, however,

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4 _____, Your Heart and Circulation, Cornet Instructional Films, Chicago 1, Illinois, 1964.

were taught by a special teacher. This special teacher was a fully certified Iowa elementary teacher. This special teacher formerly taught third grade in the Johnston Public Schools.

The regular classroom teachers were assigned to the control group and the experimental group by the Principal of the Norwoodville Elementary School. The special teacher taught all the learning tasks to both the students in the controlled ideal thermal environment classroom and those in the deviate thermal environment classroom. The special teacher was selected by the researcher and the Superintendent of Schools of the Saydel School District. This teacher was repeatedly told of the necessity to be consistent in teaching both groups. All learning tasks that were measured in this study were taught to both groups of students by the same teacher and in the same way.

Time of Day

Each week the special teacher rotated the time of day each skill and subject area was taught. This was done in order that each skill and subject area would be taught to both the control group and the experimental group at the same time of day. For example, if spelling was taught

at 10:00 a.m. in the control group and at 10:30 a.m. in the experimental group, the following week the experimental group would have spelling at 10:00 a.m. and the control group at 10:30 a.m.

Table V lists the date and time each of the skills and subject areas were taught to the two groups.

Measures of Achievement

The students' achievement scores were kept during the entire course of the study. The method used to determine students' raw scores was explained previously under the section entitled Skill and Subject Areas of this chapter.

Analysis of Data

This study was concerned simply with the question: o students attending school for a given time period, under a controlled thermal environment that is considered ideal, do better, on the whole, than students who attend for the same period of time under a controlled thermal environment that deviates quite markedly from the ideal? The statistical null hypothesis that was tested in an attempt to answer this question was: the achievement means for a given skill or subject area are the same for both of these treatment

TABLE V

DATA ON STUDENTS' SKILL AND SUBJECT ABILITY TAUGHT IN PILSEN/RCE SCHOOL

Date	Spelling Exp.	Spelling Cont.	Handwriting Exp.	Handwriting Cont.	Accuracy Exp.	Accuracy Cont.	Math. Exp.	Math. Cont.	Science Exp.	Science Cont.
1-7										
1-8	5						3	4		
1-9					3*	2*				
1-10	5*	6*					3*	4*	7	6*
1-13	6	5	2				4	5		7
1-14			2			3				
1-15	5	5	3				4	3		
1-16						3*				
1-17	6*	5*	2*				4*	5*		7*
1-20	5	6	2							
1-21			3		3					
1-22	5	6	3				3	4		
1-23			2		3*	4*				
1-24	6*	5*	2*				4*	5*		7*
1-27	5	5	2				3	4		
1-28			2		3	4				
1-29	5	6	2				3	4		
1-30			2		3*	4*				
1-31	5*	6*	2*				4*	5*		7*
2-3	5	6					4	5		
2-4					3	4				
2-5	5*	6*					3*	4*		7*
2-6					3*	4*				
2-7	5	6					4	3		7
2-10					4	3				
2-11	5	6					4	5		7
2-12					4*	3*				
2-13	5*	6*					4*	5*		7*

TABLE V (Continued)

Date	Spelling Exp.	Spelling Cont.	Handwriting Exp.	Handwriting Cont.	Accuracy Exp.	Accuracy Cont.	Math. Exp.	Math. Cont.	Science Exp.	Science Cont.
11-1	5	6					3	4	7	8
11-2										
11-3	5	6					3	4	7	8
11-4					3*	4*				
11-5	5*	6*					3*	4*	7*	8*

* Score used for analysis

Time of Day key

1: 10:00-10:20 a.m.
2: 10:30-10:50 a.m.
3: 11:00-11:20 a.m.
4: 11:30-11:50 a.m.
5: 12:30-12:50 p.m.
6: 1:00- 1:20 p.m.
7: 1:30- 1:50 p.m.
8: 2:00- 2:20 p.m.

populations.

An analysis was carried out using the last week's score collected in each skill and subject area in an effort to assess possible differences between the two treatment groups. In addition, each group was subdivided into a low ability level and into a high ability level, using the intelligence test scores, in order to test for possible interaction effects - - i.e., treatment x levels. The statistical test used for this analysis was an analysis of variance (Lindquist Type I).[5]

A second analysis was made in an effort to assess possible dissimilarities between the progress (learning) curve for the two treatment groups. This test was based on performance scores collected weekly over the entire eight week and four day time period; the time period for handwriting was four weeks. There were nine scores in spelling, science, accuracy, and mathematics. Since the subjects in the two samples have been matched or paired, a treatment (thermal condition) by week analysis of variance was used to test for possible differences not only in the overall level of the two learning curves, but more particularly in their

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5 E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education, Houghton Mifflin Company, Boston, 1956, pp. 267-273.

slopes or patterns - - i.e., particularly to test for possible interaction between treatment groups and trial weekly performances. As in the second analysis, the treatment groups were subdivided into a low ability level and into a high ability level in order to test for possible interaction effects - - i.e., trials x treatment x levels. The statistical test used for this analysis was an analysis of variance (Lindquist Type VI).[6]

Level of Significance

A level of significance had to be chosen that took into account the consequences of rejecting a true hypothesis and that of retaining a false hypothesis. Rejecting a true hypothesis is called a Type I Error; retaining a false hypothesis is called a Type II Error. Setting a very high level of significance would control a Type I Error. However, by setting a very high level of significance a Type II Error is more likely to occur. Therefore, in each experiment the level of significance must be set realizing the effects of both a Type I Error and a Type II Error.

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6 Ibid., pp. 292-297.

The results of making a Type II Error in this study does not appear to be as serious as making a Type I Error. A .01 level of significance is usually considered a high level of control over a Type I Error. A .10 level of significance is rarely used in educational research. As a compromise between the two levels, above a .05 level of significance in this study was used to test all hypotheses.

CHAPTER [illegible]

ANALYSIS [illegible] DATA

The purpose of this chapter is to analyze the data collected during the study. The data collected were the scores of the students on the various skills and subject areas. The data were analyzed for each of the skills and subject areas separately. These skills and subject areas were spelling, handwriting, accuracy, mathematics and science. An analysis was made to test the hypothesis: there is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment.

Treatment and Data

With the exception of handwriting, nine achievement scores were collected in each skill and subject area. Four handwriting scores were collected. An achievement score was collected weekly for each student in each of the skills and subject areas. The mean score for each group is presented in Table VI.

It can be observed from Table VI there were differences in the means between the experimental group and the

TABLE VI

GROUP MEANS IN EACH SELECTED SKILL AND SUBJECT AREA FOR EACH WEEK

Subject	Group	Week 1	2	3	4	5	6	7	8	9
Spelling	Exp.	10.0	12.5	14.0	13.8	14.1	15.8	14.2	15.0	16.0
	Cont.	9.9	13.7	13.6	14.3	13.8	15.8	13.9	15.5	15.6
Handwriting	Exp.	74.0	74.5	74.0	74.6					
	Cont.	73.5	73.0	73.9	74.1					
Accuracy	Exp.	14.7	12.3	16.1	17.0	16.7	19.8	17.0	17.2	20.3
	Cont.	12.5	10.3	18.1	17.0	17.8	17.3	18.2	19.0	20.4
Mathematics	Exp.	30.0	26.0	23.3	23.7	19.7	19.7	25.1	17.5	24.4
	Cont.	27.4	24.9	23.4	24.0	17.2	22.6	23.9	17.2	25.4
Science	Exp.	14.4	11.0	16.0	16.8	13.0	12.2	18.7	20.6	18.2
	Cont.	11.4	11.5	15.3	15.7	12.2	12.9	18.2	22.2	16.0

control group. However, in order to test the hypothesis, it was necessary to examine these differences more closely. Analysis of variance procedures were used to statistically test the differences between the two groups.

As stated in the previous chapter, these differences were examined using two procedures. The first procedure required the test scores made by children on tests in the last week, in each skill and subject area. The difference in means between the experimental group and the control group was tested using the Analysis of Variance-Type I procedure.

A second analysis was used in an effort to assess possible dissimilarities between the progress (learning) curve for the two groups. This test was based on scores collected weekly over the entire time period. Since the students in the two groups had been matched, a treatment by week by subject analysis of variance procedure was used to test for possible differences not only in the overall level of the two learning groups, but more particularly in their curve, i.e., particularly to test for possible interaction between the two groups. The test used for this analysis was the Analysis of Variance - Type VI procedure.

In each analysis both treatment groups were divided into a high and low ability level using the criteria previously stated.

Analysis of Spelling Scores

Analysis of Variance by Type I Design

The means of the scores collected on the last spelling list are shown in Table VII. The analysis of variance summary of these data is presented in Table VIIa.

From Table VIIa it can be observed that the difference in means between the two ability levels was not significant. The difference in means between the two treatment groups was also not significant.

The interaction effect between treatments and levels is shown graphically in Figure 3. This interaction was not significant.

Analysis of Variance by Type VI Design

The performance of the students in all the weekly spelling trials is reported in Table VIII. Table VIIIa is the analysis of variance summary for the spelling scores for all weekly trials. The difference in the mean scores for the two groups was not significant. The difference in means for the ability levels was also not significant.

TABLE VII

GROUP MEANS FOR SPELLING SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Means
Exp.	17.2	14.7	16.0
Cont.	16.6	14.5	15.6
Means	16.9	14.6	15.8

TABLE VIIa

ANALYSIS OF VARIANCE SUMMARY
SPELLING SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	29.7985		
Levels	1	56.3180	1.9974	1,20
error (b)	20	28.4455		
Within S	22	24.0000		
Treat.	1	1.4545	0.0553	1,20
Treat. x Levels	1	0.3638	0.0138	1,20
error (w)	20	26.3091		
Total	43			

F_{05} = 4.35 df=1,20

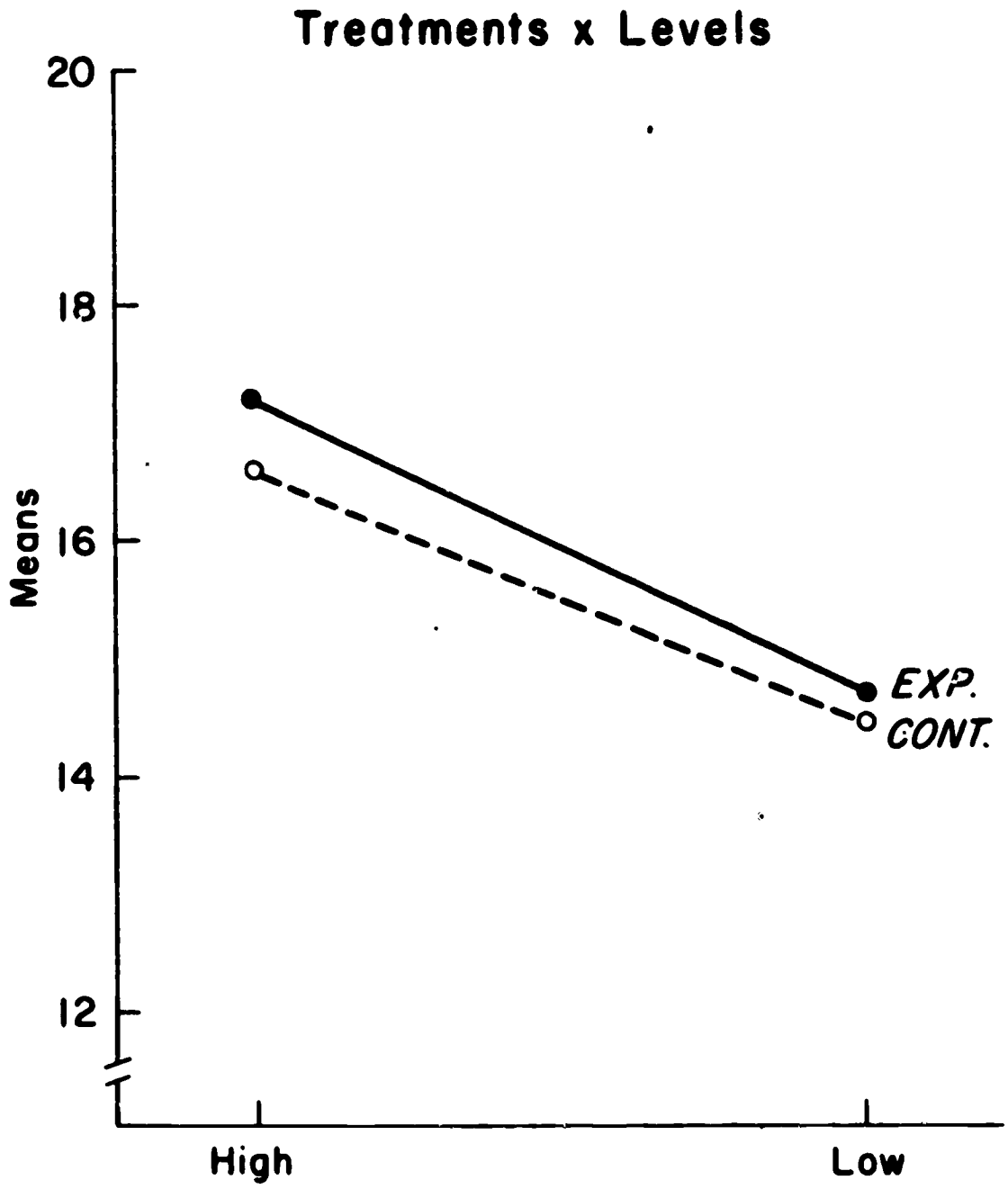

Figure 3

INTERACTION FOR SPELLING SCORES - LAST WEEK ONLY

TABLE VII

GROUP MEANS FOR SPELLING SCORES -- ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	12.2	13.5	15.5	15.5	15.5	17.2	15.9	16.3	17.2	15.4
Cont.	12.2	14.7	15.3	15.6	14.5	16.9	15.9	16.7	16.6	15.3
Means	12.2	14.1	15.4	15.6	15.0	17.0	15.4	16.5	16.9	15.4

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	7.8	11.5	12.5	12.0	12.6	14.5	12.5	13.7	14.7	12.4
Cont.	7.5	12.6	11.9	12.9	13.1	14.7	12.9	14.3	14.5	12.7
Means	7.7	12.1	12.2	12.5	12.9	14.6	12.7	14.0	14.6	12.6

TABLE V[illegible] (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	10.0	12.5	14.0	13.8	14.1	15.8	14.2	15.0	16.0	13.9
Cont.	9.9	13.7	13.6	14.3	13.8	15.8	13.9	15.5	15.6	14.0

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	15.4	12.4	13.9
Cont.	15.3	12.7	14.0

TABLE VIII

ANALYSIS OF VARIANCE SUMMARY
SPELLING SCORES - ALL NINE WEEKS

Source	df	ms	F	(df)
Between S	21	273.1374		
Levels	1	780.8809	3.0853	1,20
error (b)	20	240.4322		
Within S	374	22.7167		
Trials	3	130.6006		
Treatment	1	0.0868	0.0020	1,20
Treat. x Trials	3	3.8339	3.6172	3,180
Trials x Levels	3	0.3610		
Treat. x Levels	1	5.1123	0.0178	1,20
Treat. x Trials x Levels	3	1.2498	0.2543	3,180
Error (w)	348	21.4-033		
Error$_1$(w)	168	4.9188		
Error$_2$(w)	20	287.4820		
Error$_3$(w)	180	4.9257		
Totals	588			

$F_{.05} = 4.35$ df=1,20 *F significant
$F_{.05} = 2.00$ df=3,180

The interaction effects examined were (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels. These interaction effects are illustrated in Figure 4. Of these interactions, none were significant.

Analysis of Handwriting Scores

Analysis of Variance by Type I Design

The means for the last handwriting trial are shown in Table IX. Table IXa contains the analysis of variance summary for the last trial handwriting scores shown in Table IX. The difference in means for the two ability levels and for the two groups were not significant.

The interaction effect between treatments and levels on this last handwriting trial was not significant. The interaction effect is presented graphically in Figure 5.

Analysis of Variance by Type VI Design

The means for the groups by levels for all handwriting trials are presented in Table X. Table Xa, the analysis of variance summary for all trials, shows that the difference between the groups was not statistically significant.

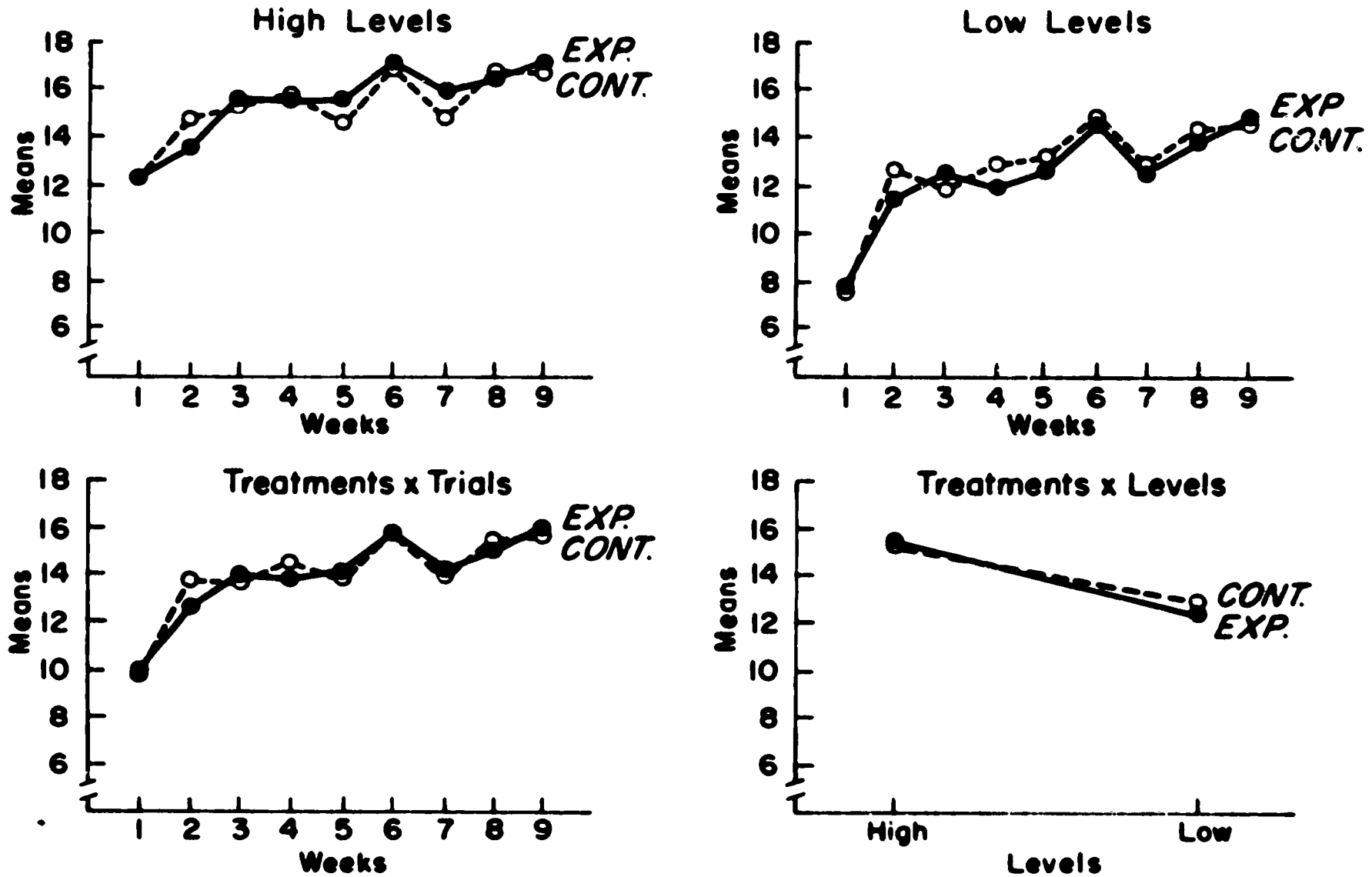

Figure 4

INTERACTION FOR SPELLING SCORES-ALL NINE WEEKS

TABLE IX

GROUP MEANS FOR HANDWRITING SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Means
Exp.	76.5	72.6	74.6
Cont.	74.9	73.3	74.1
Means	75.7	73.0	74.4

TABLE X

ANALYSIS OF VARIANCE SUMMARY
HANDWRITING SCORES - LAST WEEK ONLY

Source	df	ms	F	(cf)
Between S	21	20.3183		
Levels	1	76.4561	4.2333	1,20
error (b)	20	18.0383		
Within S	22	20.0345		
Treat.	1	3.2715	0.1331	1,20
Treat. x Levels	1	11.0019	0.5333	1,20
error (w)	20	21.1333		
Total	43			

F_{05} = 4.35 df=1,20 *F Significant

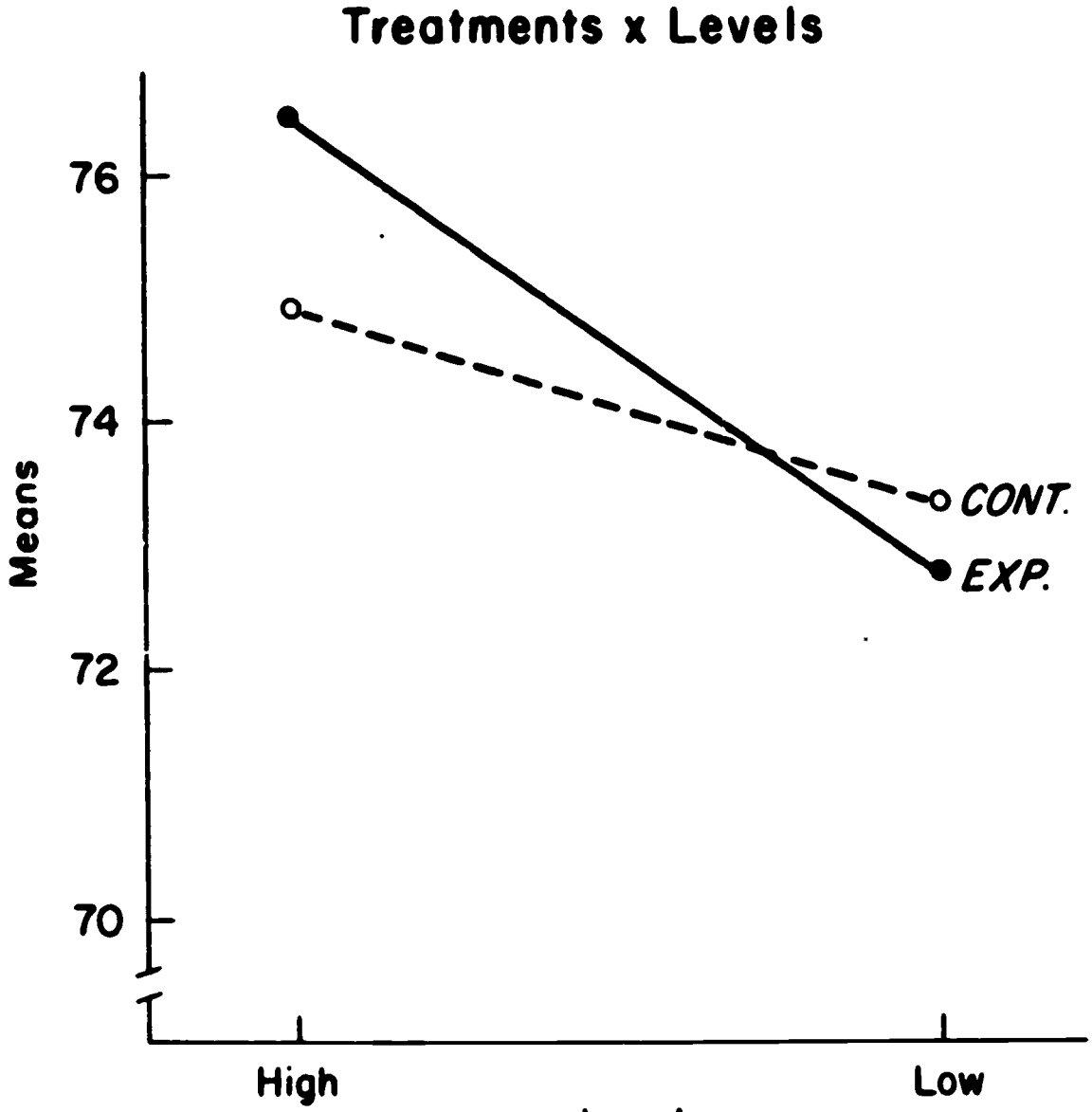

Figure 5

INTERACTION FOR HANDWRITING SCORES - LAST WEEK ONLY

TABLE 4

GROUP MEANS FOR MATHEMATICS SCORES - ALL TOTAL MEAN
Treatments x Weeks x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	73.0	73.2	73.4	73.8	73.7
Cont.	74.0	74.7	75.2	74.8	74.9
Means	73.5	73.4	74.2	73.7	73.9

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	73.8	72.8	72.8	72.8	72.8
Cont.	72.2	71.4	71.8	71.3	71.8
Means	72.8	72.8	72.1	72.0	72.2

Treatments x Weeks

Groups (Treat.)	Weeks 1	2	3	4	Means
Exp.	74.0	74.5	74.8	74.8	74.3
Cont.	73.5	73.8	73.8	74.1	73.8

TABLE X (Continued)

Treatments & Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	75.7	72.8	74.3
Cont.	74.9	72.3	73.6

TABLE Xa

ANALYSIS OF VARIANCE SUMMARY
HANDWRITING SCORES - ALL FOUR WEEKS

Source	df	ms	F	(df)
Between S	21	43.9021		
Levels	1	332.7570	9.5070*	1,20
error (b)	20	34.7094		
Within S	154	10.5357		
Trials	3	3.7213		
Treatment	1	19.1172	0.1965	1,20
Treat. x Trials	3	4.2694	0.9593	2,60
Trials x Levels	3	2.0130		
Treat. x Levels	1	1.0937	0.0112	1,20
Treat. x Trials x Levels	3	4.0286	0.8882	3,60
Error (w)	140	17.7444		
$Error_1(w)$	60	4.2716		
$Error_2(w)$	20	97.7894		
$Error_3(w)$	60	4.5555		
Totals	175			

F_{05} = 4.35 df=1,20 *F Significant
F_{05} = 2.76 df=3,60

The mean for the high ability level groups for handwriting was 75.3 and the mean for the low ability level groups was 72.8. This difference between levels was statistically significant at the .05 level (F=9.5870).

None of the interactions were significant. The curves of the interactions (1) treatments x trials x levels, (2) treatments x trials, and (3) treatments x levels are shown in Figure 6.

Analysis of Accuracy Scores

Analysis of Variance by Type I Design

The mean scores for the last accuracy trial are reported in Table XI. Table XIa contains the analysis of variance summary for the scores on the last trial.

The difference in mean scores for the two groups was not significant. The difference in mean scores for the two ability levels was also not significant.

The interaction of treatments x levels was examined. The analysis of variance summary table shows this interaction to be not significant. This interaction is illustrated in Figure 7.

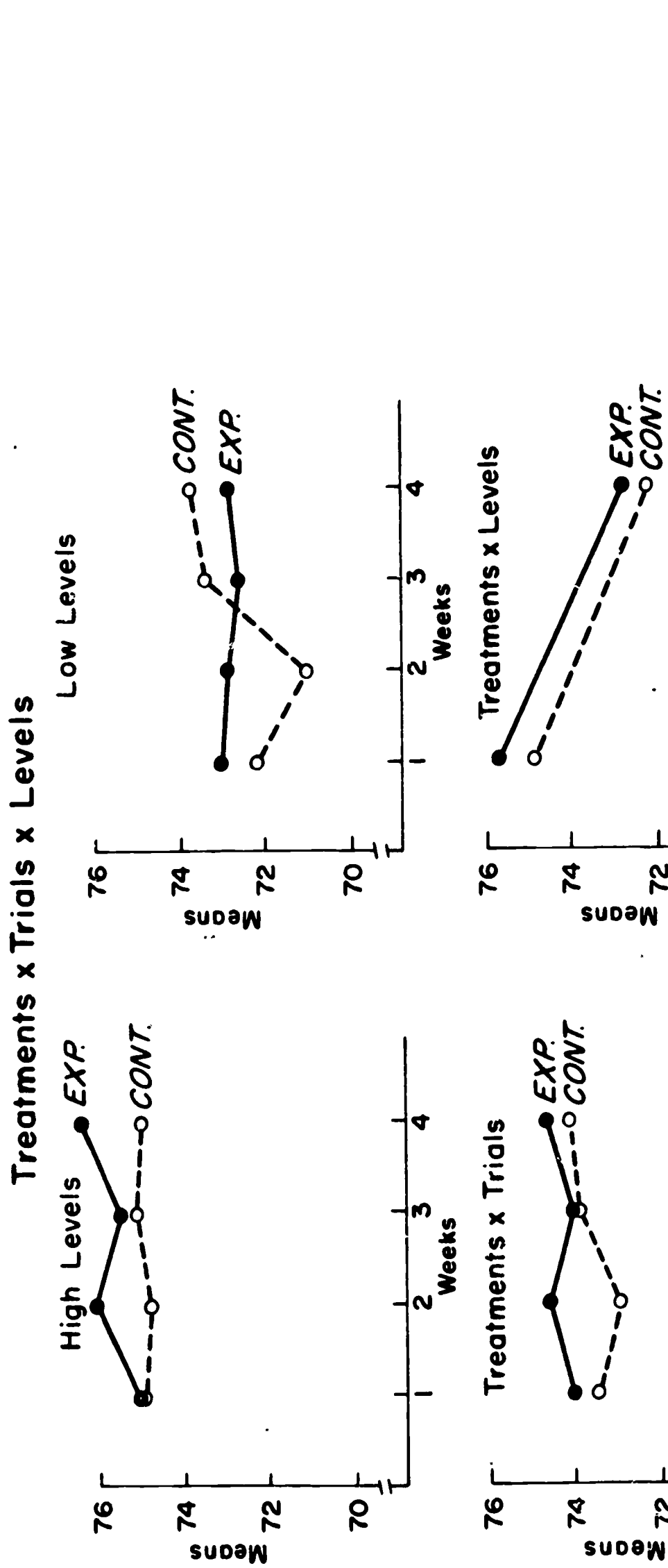

Figure 6
INTERACTION FOR HANDWRITING SCORES - ALL FOUR WEEKS

Table 11

CACTUS PLANTS FOR INDUSTRIAL SCHOOLS - LAST WEEK ONLY

2 Treatments x Levels

Treatments (Hours)	High Levels	Low Levels	Mean
Exp.	19.5	20.1	20.3
Cont.	22.0	18.8	20.4
Means	21.3	19.3	20.4

Table 11a

ANALYSIS OF VARIANCE
ACCURACY SCORES - LAST WEEK ONLY

Source	df	MS	F	(df)
Between S	21	32.3733		
Levels	1	6.1333	1.2102	1,20
Error (b)	20	31.4333		
Within S	22	4.7.. 21		
Treat.	1	3.0313	0.0020	1,20
Treat. x Levels	1	21.4545	0.0933	1,20
Error (w)	21	31 3717		
Total	43			

F_{05} = 4.35 (1,20 *= Significant

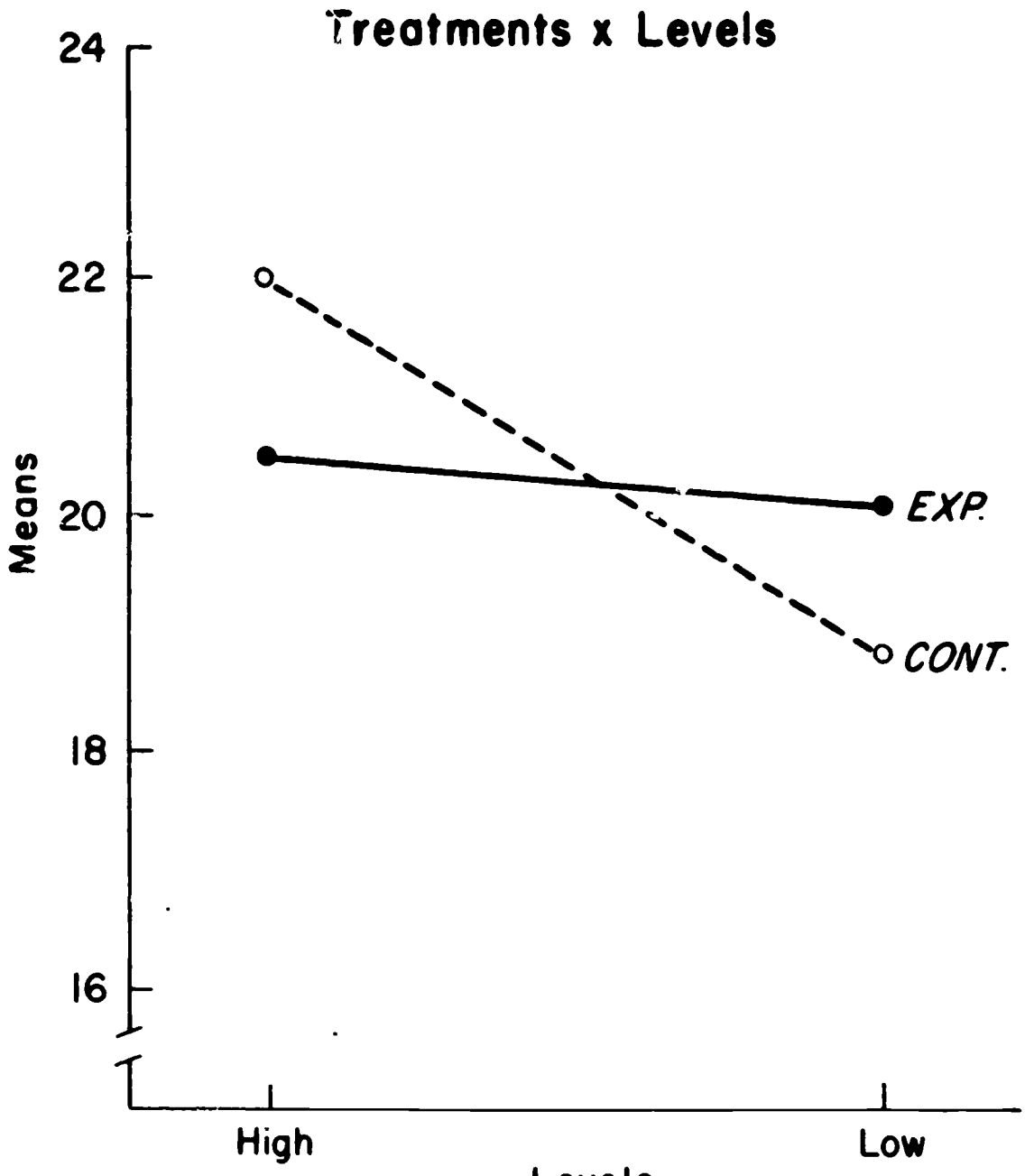

Figure 7

INTERACTION FOR ACCURACY SCORES - LAST WEEK ONLY

Analysis of Variance of Time - Level I

The means of the accuracy scores for the two treatments by ability are reported in Table XII. From Table XIIa, which presents the analysis of variance summary for the scores, it can be seen that the difference between the groups was not statistically significant. The difference between ability levels was not significant.

The interaction effects shown in Table XII are presented in Figure 3 in graphic form. Only the interaction of treatments x ability was statistically significant at the .05 level ($F=4.13$). The interaction for treatments x ability x levels and for treatments x levels was not significant.

Analysis of Mathematics Scores

Analysis of Variance by Type I Error

The mean scores for the Low Mathematics Ability are reported in Table XIII. The analysis of variance summary is presented in Table XIIIa. The difference in mean scores for the two groups was not significant. The difference in mean scores for the ability levels was significant ($F=3.87$). The mean of the high ability level was 27.5 and the mean for

TABLE XII

GROUP MEANS FOR ACCURACY SCORES - ALL HIGH WORDS
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	16.6	17.5	17.0	16.8	19.[illegible]	21.5	17.1	17.2	20.5	17.5
Cont.	12.5	13.2	13.5	14.3	14.6	17.9	20.6	19.8	22.9	17.6
Means	14.2	15.4	15.3	[illegible]	17.1	19.9	19.9	[illegible]	[illegible]	17.7

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cont.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Means	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE XII (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	14.7	12.3	16.1	17.0	16.7	19.8	17.0	17.2	20.3	16.8
Cont.	12.5	10.3	18.1	17.0	17.8	17.3	16.2	19.0	20.4	16.7

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	17.5	16.1	16.8
Cont.	17.6	15.9	16.7

TABLE [illegible]

ANALYSIS OF [illegible]
ACCURACY SCORE - [illegible]

Source	df	MS	F	[illegible]
Between S	21	[illegible]		
Levels	2	[illegible]	[illegible]	[illegible]
error (b)	20	[illegible]		
Within S	374	[illegible]		
Trials	9	[illegible]		
Treatment	1	[illegible]	[illegible]	[illegible]
Treat. x Trials	9	[illegible]	[illegible]*	[illegible]
Trials x Levels	2	[illegible]		
Treat. x Levels	2	[illegible]	[illegible]	[illegible]
Treat. x Trials x Levels	18	[illegible]	[illegible]	[illegible]
Error (w)	340	[illegible]		
Error$_1$(w)	20	[illegible]		
Error$_2$(w)	20	2021.0525		
Error$_3$(w)	200	20[illegible].4000		
Totals	395			

$F_{.05}$ = 4.35 df=1,20 *F Significant
$F_{.05}$ = 2.00 df=8,160

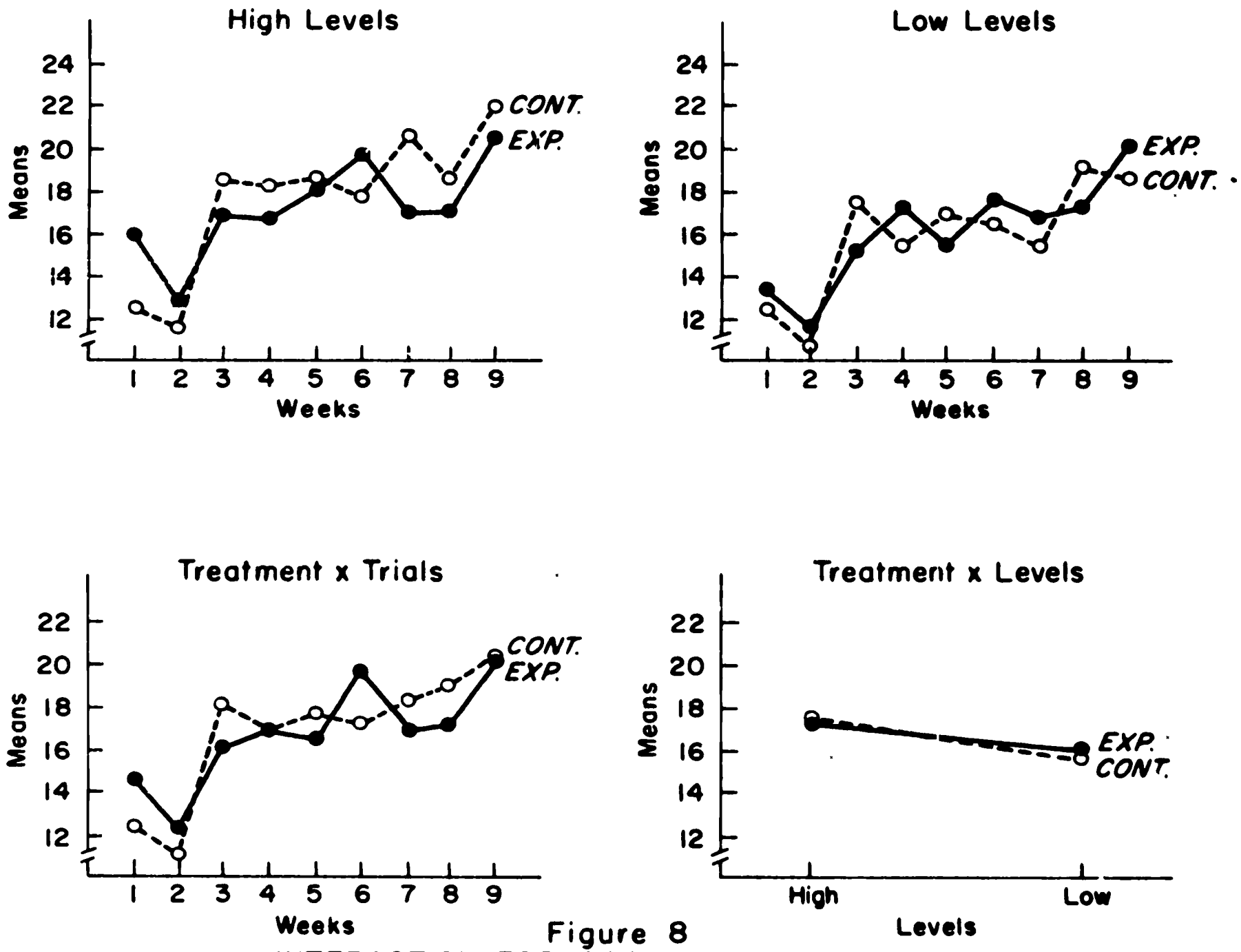

Figure 8
INTERACTION FOR ACCURACY - ALL NINE WEEKS

TABLE XII

GROUP MEANS FOR MATHEMATICS SCORES - LAST MARKING ONLY

(Treatments x Levels)

Groups (Treat.)	High Levels	Low Levels	Mean
Exp.	28.3	21.1	24.7
Cont.	26.8	22.0	23.4
Means	27.5	21.6	24.5

TABLE XIII

ANALYSIS OF VARIANCE
MATHEMATICS SCORES - LAST MARKING ONLY

Source	df	MS	F	(.05)
Between S	21	43.4[illegible]		
Levels	1	321.[illegible]	8.0107*	4.20
Error (b)	20	39.[illegible]		
Within S	22	20.8[illegible]		
Treat.	1	12.[illegible]	[illegible]	4.20
Treat. x Levels	1	8.[illegible]	0.[illegible]	4.20
Error (w)	20	23.[illegible]		
Total	43			

$F_{.05}$ = 4.35 df=1,20 *F Significant

the low ability level was 22.2.

The interaction on the last trial of treatments x levels was not significant. This interaction is illustrated graphically in Figure 9.

Analysis of Variance by Type VI Design

Table XIV contains the mean scores of the mathematics trials for all nine weeks. Table XIVa contains the analysis of variance summary of all weekly mathematics scores.

From Table XIVa it can be observed that the difference between groups was not significant.

However, the difference between the high ability level and low ability level was significant (F=14.3488). The mean for the high ability level was 25.8. The mean for the low ability level was 20.4.

Figure 10 illustrates the curves for the interactions. The F values of all the interactions were not significant.

Analysis of Science Scores

Analysis of Variance by Type I Design

The means received in the science test for the last Friday is presented in Table XV. The analysis of variance

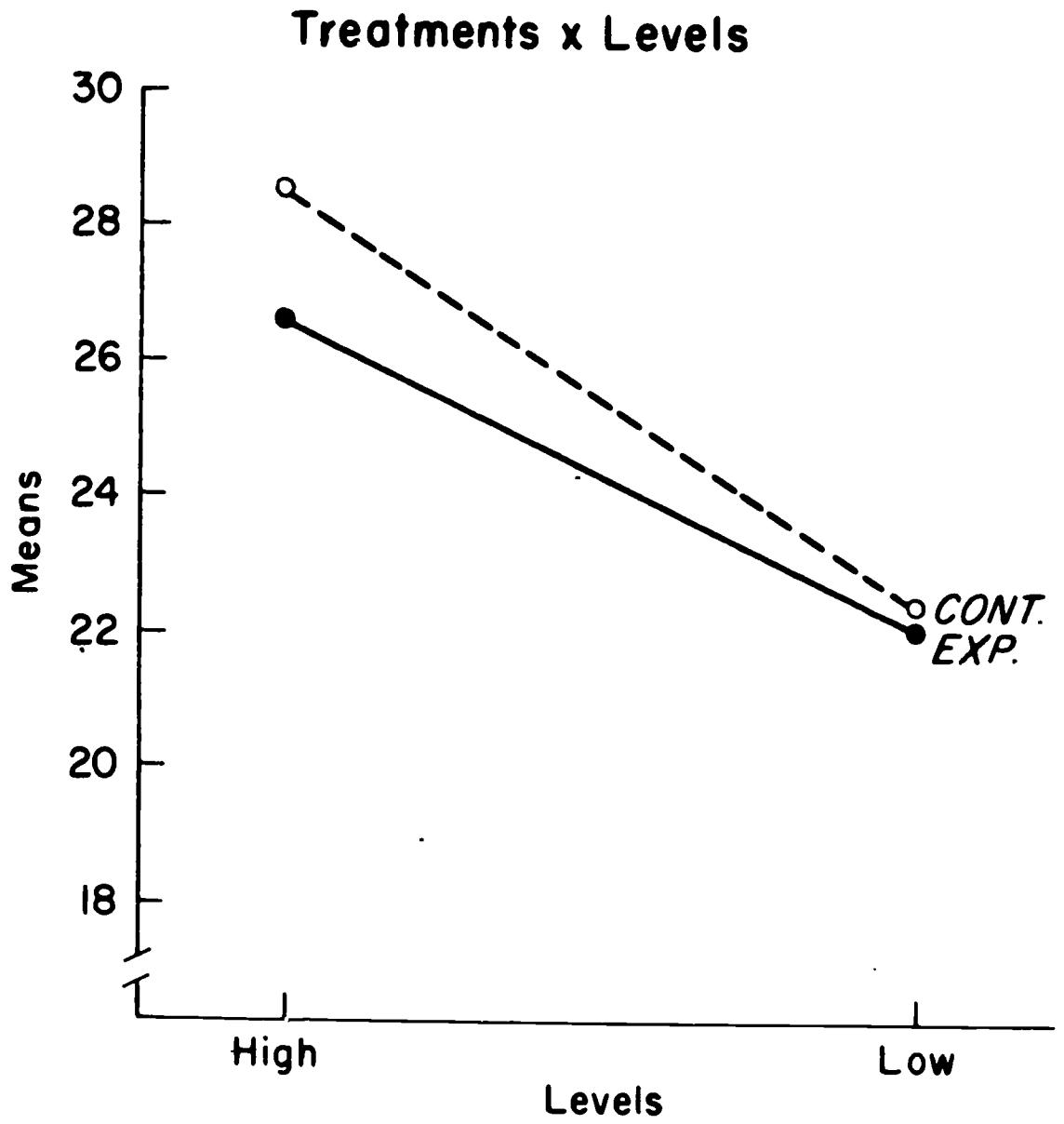

Figure 9

INTERACTION FOR MATHEMATICS SCORES - LAST WEEK ONLY

TABLE XIV

GROUP MEANS FOR MATHEMATICS SCORES - ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	30.0	29.8	26.1	24.4	22.1	21.6	26.8	21.5	26.6	25.4
Cont.	28.7	26.5	27.8	26.3	20.6	27.9	27.2	22.1	28.5	26.2
Means	29.4	28.1	27.0	25.3	21.4	24.8	27.0	21.8	27.5	25.8

Low Levels

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	30.0	22.3	20.5	23.1	17.4	17.7	23.4	13.5	22.1	21.1
Cont.	26.1	23.4	18.9	21.8	13.7	17.4	20.6	12.4	22.4	19.6
Means	28.0	22.8	19.7	22.5	15.5	17.5	22.0	12.9	22.2	20.4

TABLE XIV (Continued)

Treatments x Trials

Groups (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	30.0	26.0	23.3	23.7	19.7	19.7	25.1	17.5	24.4	23.3
Cont.	27.4	24.9	23.4	24.0	17.2	22.6	23.9	17.2	25.4	22.9

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	25.4	21.1	23.3
Cont.	26.2	19.6	22.9

TABLE XIVa

ANALYSIS OF VARIANCE SUMMARY
MATHEMATICS SCORES - ALL NINE WEEKS

Source	df	ms	F	(df)
Between S	21	333.8978		
Levels	1	2929.1152	14.3488*	1,20
error (b)	20	204.1369		
Within S	374	55.3594		
Trials	8	557.7099		
Treatment	1	13.4570	0.0332	1,20
Treat. x Trials	8	33.8713	1.4689	8,160
Trials x Levels	8	57.8911		
Treat. x Levels	1	121.1094	0.2986	1,20
Treat. x Trials x Levels	8	23,3455	1.0124	8,160
Error (w)	340	44.6685		
$Error_1(w)$	160	21.1631		
$Error_2(w)$	20	405.5904		
$Error_3(w)$	160	23.0587		
Total	395			

F_{05} = 4.35 df=1,20 *F Significant
F_{05} = 2.00 df=8,160

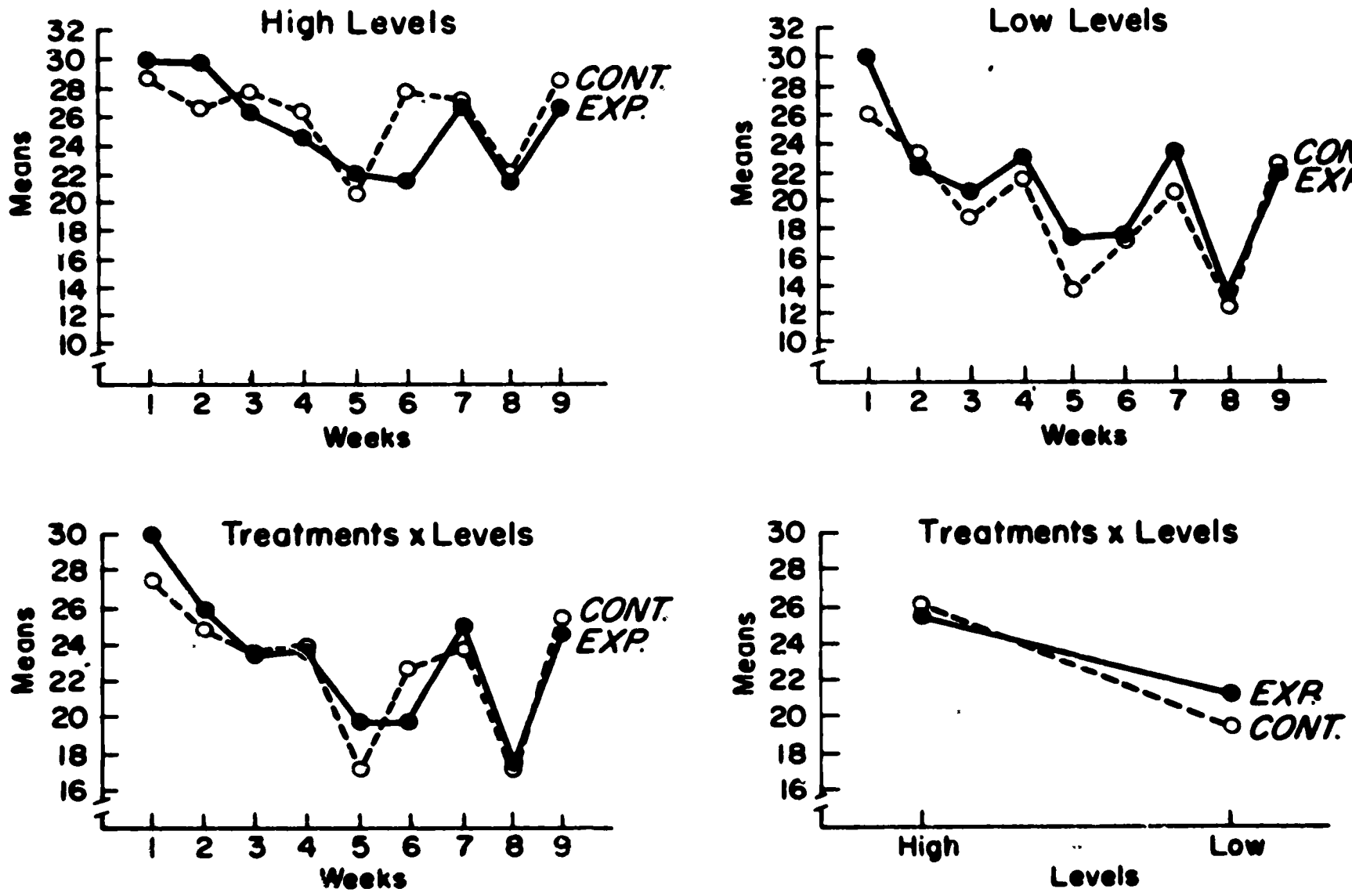

Figure 10
INTERACTION FOR MATHEMATICS SCORES - ALL NINE WEEKS

TABLE XV

GROUP MEANS FOR SCIENCE SCORES - LAST WEEK ONLY

Treatments x Levels

Groups (Treat.)	High Levels	Low Levels	Mean
Exp.	21.8	14.5	18.2
Cont.	16.6	15.4	16.0
Means	19.2	15.0	17.1

TABLE XVa

ANALYSIS OF VARIANCE SUMMARY
SCIENCE SCORES - LAST WEEK ONLY

Source	df	ms	F	(df)
Between S	21	80.1732		
Levels	1	200.8181	2.7086	1,20
error (b)	20	74.1409		
Within S	22	84.2727		
Treat.	1	52.3636	0.6151	1,20
Treat. x Levels	1	99.0000	1.1629	1,20
error (w)	20	85.1318		
Total	43			

F_{05} = 4.35 df=1,20 *F Significant

summary of the last trial of the science scores is presented in Table XVa. The difference in mean scores between the experimental group and the control group was not significant. The difference in mean scores between the high ability level and the low ability level was also not significant.

The interaction effect of treatments x levels was not statistically significant. This interaction is shown graphically in Figure 11.

Analysis of Variance by Type VI Design

The means of the nine weekly science scores are reported in Table XVI. Table XVIa contains the analysis of variance for the scores on all the weekly science trials. The difference in means between the experimental group and the control group was not statistically significant. Also not significant was the difference between the ability levels.

The F value for the interactions (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels was not significant. The curves of all the weeks, groups, and levels are illustrated in Figure 12.

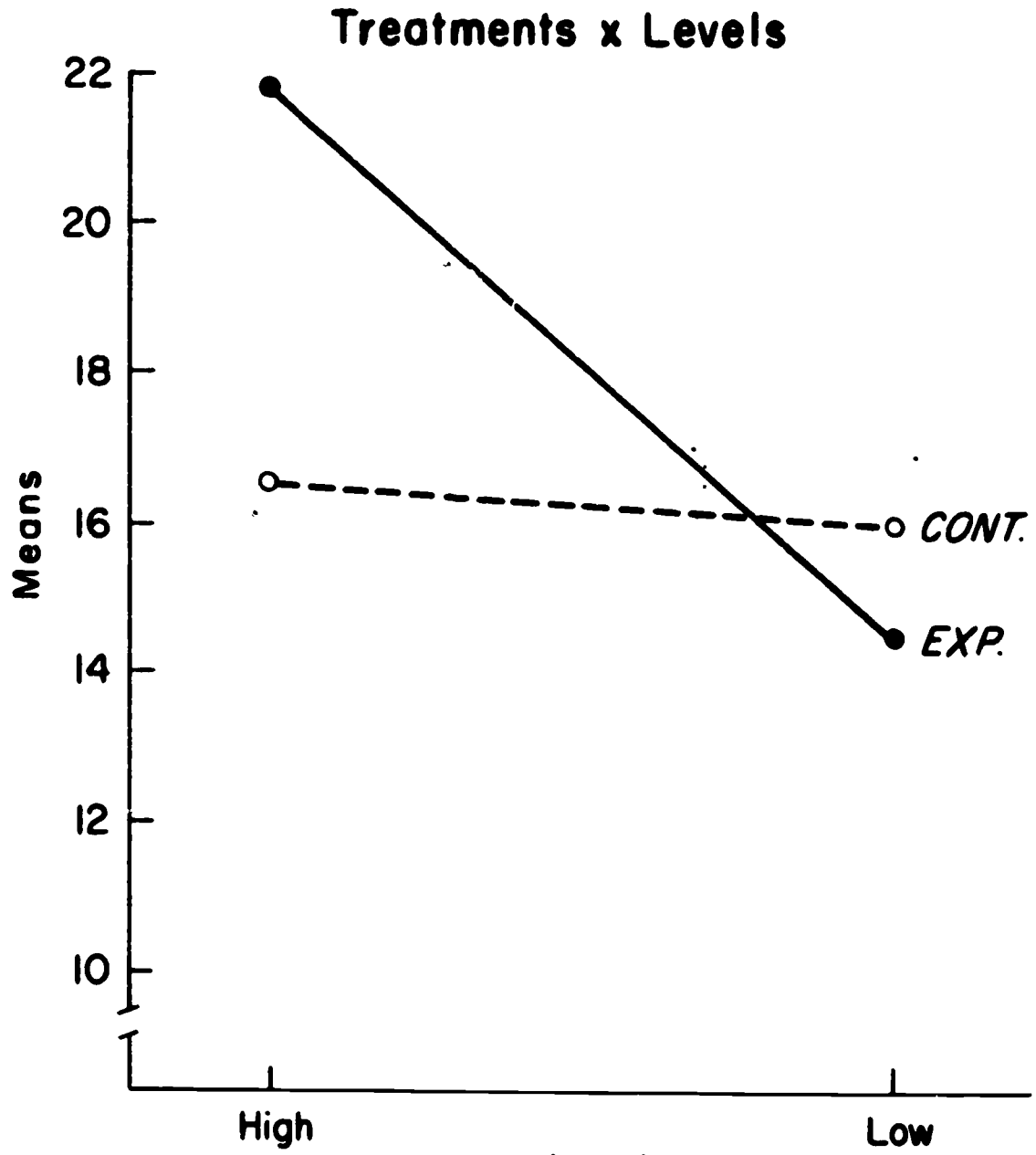

Figure 11

INTERACTION FOR SCIENCE SCORES - LAST WEEK ONLY

TABLE XVI

GROUP MEANS FOR SCIENCE SCORES - ALL NINE WEEKS
Treatments x Trials x Levels

High Levels

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	15.3	12.2	16.7	20.6	15.1	15.8	21.1	24.5	21.8	18.1
Cont.	12.4	12.8	16.8	17.4	13.8	13.5	19.7	23.3	16.6	16.3
Means	13.8	12.5	16.8	19.0	14.5	14.7	20.4	23.9	19.2	17.2

Low Levels

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	13.5	9.9	15.4	13.0	10.8	8.6	16.4	16.6	14.5	13.2
Cont.	10.5	10.3	13.7	14.1	10.5	12.2	16.7	21.1	15.4	13.8
Means	12.0	10.1	14.5	13.5	10.7	10.4	16.5	18.9	15.0	13.5

TABLE XVI (Continued)

Treatments x Trials

Group (Treat.)	Weeks 1	2	3	4	5	6	7	8	9	Means
Exp.	14.4	11.0	16.0	16.8	13.0	12.2	18.7	20.6	18.2	15.7
Cont.	11.4	11.5	15.3	15.7	12.2	12.9	18.2	22.2	16.0	15.0

Treatments x Levels

Groups (Treat.)	Levels High	Low	Means
Exp.	17.5	16.1	16.8
Cont.	17.6	15.8	16.7

[illegible]

[illegible] SUMMARY
SCIENCE [illegible] WEEKS

Source	df	ms	F	(df)
Between S	21	471.9075		
Levels	1	1345.7070	3.1426	1,20
error (b)	20	428.2175		
Within S	374	48.7926		
Trials	8	435.6960		
Treatment	1	37.5359	0.0964	1,20
Treat. x Trials	8	21.8525	1.0597*	8,160
Trials x Levels	8	17.5760		
Treat. x Levels	1	155.3125	0.3984	1,20
Treat. x Trials x Levels	8	24.8413	1.2046	8,160
Error (w)	346	40.1042		
$Error_1$(w)	160	20.6953		
$Error_2$(w)	20	380.8549		
$Error_3$(w)	160	20.6215		
Total	395			

F_{05} = 4.35 df=1,20 *F Significant
F_{05} = 2.00 df=8,160

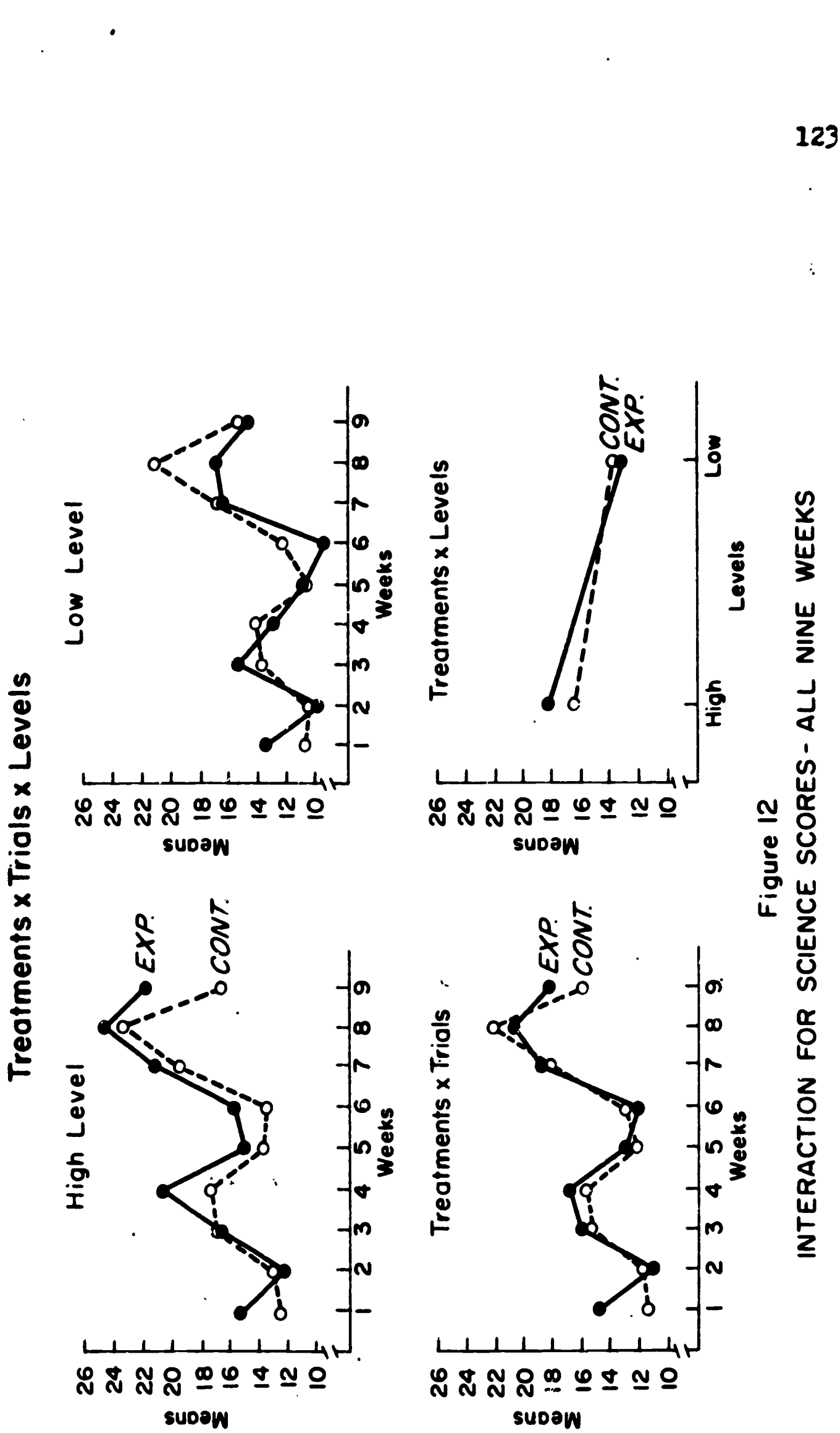

Figure 12
INTERACTION FOR SCIENCE SCORES- ALL NINE WEEKS

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study tested the hypothesis: there is no difference in pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment. A .05 level of significance was used to test all hypotheses.

Procedures

Through the joint cooperation of the Saydel School District, Saydel, Iowa, the Lennox Industries Inc. and the University of Iowa, the study was conducted using the following procedures:

1. Two matched groups of fifth grade students were chosen from the Saydel School District. Twenty-two matched pairs of students were selected for the two groups. The students were matched by intelligence test scores, achievement test results, sex, age, and family background.

   By the flip of a coin one group was designated to be the experimental group. The second group was designated to be the control group.

   Both the experimental group and the control group were divided into a high ability level and a low ability level on the basis of intelligence test scores. The eleven students

having the highest intelligence test scores in each group were considered high ability level and the remaining eleven students in each group were considered the low ability level.

2. The Lennox Industries Inc. furnished a two room school to conduct the study. Both classrooms were identical in all relevent physical aspects. Any desirable thermal environment could be maintained in either classroom.

3. In one classroom a thermal environment that was considered as ideal was maintained. These ideal conditions were established after an extensive review of literature and consulting with authorities in thermal environment control. The students in the experimental group were placed in the ideal thermal environment.

   In the second classroom a thermal environment was maintained that was different than that of the ideal thermal environment. This second classroom thermal environment was called deviate. The students in the control group were placed in the deviate thermal environment.

4. Regular Saydel School teachers taught the students their customary school subjects. A certified and experienced elementary teacher was employed to teach both groups of students in certain selected skills and subject areas. This special teacher taught spelling, handwriting, accuracy, mathematics, and science to the students. All instruction in these areas was presented using an acceptable teaching method.

5. In the selected areas all teaching instruction to both groups of students was identical. The students in both groups spent the same amount of time on each area. In addition, the students performed each task on the same and,

in effect, at the same time of day.

A weekly achievement score was collected from all students in each selected skill and subject area. The achievement score collected was the end of the week's lesson in each area.

6. The students were in the study for an eight week and four day time period. (Approximately nine weeks).

7. At the end of the nine weeks period the data on the two groups were statistically analyzed. The statistical analyses used were analysis of variance procedures. The scores of the last week in each area were analyzed using Lindquist - Type I procedures. The scores of all weeks in each area were examined using Lindquist - Type VI procedure.

Summary of the Analyses

Last Trial Summary

A summary of scores collected in the last week is presented in Table XVII. This table contains the group means of the scores for the last week in each skill and subject area and the F value for the difference in the means for the two groups. The ability level means and the F value is included. The F value for the interaction between levels and treatments is also presented in Table XVII. It was observed from this table that there was no statistically significant difference between group means for the last trial results. None of the interactions were

TABLE XVII

SUMMARY OF SCORES FOR THE LAST WEEK,
GROUP MEANS AND INTERACTIONS

Skill or Subject	Group Means (Treatment)			Ability Means (Levels)			Interaction (Treat. x Levels)
	Exp.	Cont.	F Value	High	Low	F Value	F Value
Spelling	16.0	15.6	0.0553	16.9	14.6	1.9374	0.0138
Handwriting	74.6	74.1	0.1051	75.7	73.0	4.2313	0.3533
Accuracy	20.3	20.4	0.0019	21.3	19.5	3.1192	0.3966
Mathematics	24.4	25.4	0.1444	27.5	22.2	8.9378	0.0789
Science	18.2	16.0	0.0111	19.2	15.0	2.7014	1.1629

*F Significant

significant.

The spelling score means for the experimental group and the control group were 16.0 and 15.6, respectively. In handwriting the mean for the experimental group was 74.6 and the mean for the control group was 74.1. On the accuracy skill tests the means were 20.3 and 20.4 for the experimental and control groups, respectively. In mathematics the mean for the control group was above that of the experimental group. The mean for the experimental group was 24.4 and for the control group it was 25.4. In science the mean score for the students in the experimental group was 18.2 and those in the control group achieved a mean of 16.0.

From Table XVII it was seen that the difference in mean scores between the high ability level and the low ability level was significant in mathematics, in favor of the high ability level. The differences in the mean scores between the two ability levels were not significant in the other skills and subjects.

All Trials Summary

The analysis of all trials is presented in Table XVIII. The means were presented for the high and low ability levels and for the experimental and control groups. F

TABLE XVIII

SUMMARY OF ALL WEEKS SCORES, GROUP MEANS AND INTERACTIONS

Skill or Subject	Ability Means (Levels)			Group Means (Treatment)			Interaction F Values		
	High	Low	F Value	Exp.	Cont.	F Value	Treat. x Trials	Treat. x Levels	Treat. x Trials x Levels
Spelling	15.4	12.6	3.0883	13.9	14.0	0.0020	0.6172	0.0178	0.2543
Handwriting	75.3	72.6	9.5870*	74.3	73.6	0.1955	0.9393	0.0112	0.8882
Accuracy	17.6	16.0	1.1465	16.8	16.7	0.0022	2.7599*	0.0124	1.1423
Mathematics	25.8	20.4	14.3486*	23.3	22.9	0.0332	1.4699	0.2986	1.0124
Science	17.2	13.5	3.1426	15.7	15.0	0.0964	1.0597	0.3984	1.2046

*F Significant

values were presented for the differences in means between the two ability levels and for the two groups. The interaction F values for (1) treatments x trials, (2) treatments x levels, and (3) treatments x trials x levels are also given in the table.

The means on all spelling trials were 13.9 for the experimental group and 14.0 for the control group. The mean for the experimental group and the mean for the control group was 74.3 and 73.8, respectively, on all handwriting trials. On all accuracy test trials the mean achieved by the experimental group was 16.8 and 16.7 for the control group. When all trials were considered in mathematics, the mean for the experimental group was 23.3 and the mean for the control group was 22.9. A mean of 15.7 for all trials was achieved by the experimental group in science. The control group achieved a mean of 15.0 for all science trials.

None of the F values for the differences between the means of the two groups were statistically significant.

In two areas statistically significant differences were found between the high ability level and the low ability level. These two areas were handwriting and mathematics. The high ability level students achieved a

mean of 75.3 in all handwriting trials while the low ability level students had a mean of 72.6 for the subject. This difference was significant at the .05 level. For all mathematics trials the high ability level students had a mean of 25.8 and the mean for the low ability level students was 20.4. This difference was significant.

The only interaction that was statistically significant was that between treatments and trials in the accuracy tests.

Conclusions

The test conducted was of the null hypothesis: there is no difference between pupil learning in a controlled ideal thermal environment and in a controlled deviate thermal environment. The results of this study lead to an acceptance of this null hypothesis.

The conclusion reached by this study was that student learning is not affected by attending school in a controlled ideal thermal environment.

Recommendations

At the conclusion of this study, it was evident that measuring the effects of thermal environment on learning had just begun. Using the experience gained in con-

ducting this study the following recommendations are submitted as specific areas in which additional research is needed:

Recommendation No. 1

The next researcher would be well advised to duplicate some of the tasks, skills, and subject areas that were used in previous studies. This would help to confirm or reject the findings of previous studies. It may be found that pupil learning is affected by the thermal environment, but that our measurement instruments are too gross in school subjects to detect the differences.

The findings of this study contradict, to a certain extent, the findings of the first study conducted by Dr. Charles Peccolo. This researcher does not propose that one study is right and the other wrong. A careful examination of the two studies will reveal several dissimilarities in the procedures in the two studies.

Recommendation No. 2

Future studies might prove more valuable if conducted over a longer time period than was used in this research.

All individuals associated with this study realize that research has only begun to scratch the surface

in measuring the effects of thermal environment on pupils. Education is a long term experience, and perhaps a nine week time period is too short a period in which to measure the effect of an ideal thermal environment.

Recommendation No. 3

Future studies ought to be conducted jointly with a Department of Home Economics to measure nutritional effects of the thermal environment.

The private catering service observed that they could tell which room had the ideal thermal environment as those students had heartier appetites. (The same caterers had been used in previous studies).

Recommendation No. 4

Future studies should make an attempt to measure the effect of thermal environment on student attitudes toward school.

The teachers involved in this present study noticed that the students in the ideal thermal environment were not as restless as the students in the deviate environment.

Recommendation No. 5

Future research should make a conscious effort to involve a greater number of boys and girls covering a wider

range in socio-economic backgrounds.

Forty-four boys and girls were involved in the current study. By chance, these particular students were from a relatively low socio-economic level.

Recommendation No. 6

Future research should be conducted using students from all grade levels.

Recommendation No. 7

Future research might prove valuable if conducted during meteorologically contrasting months of the calendar year. (In this study heated air was never added to the ideal classroom while the younsters were in the classroom).

Recommendation No. 8

Further research should be conducted to examine the effect of an ideal thermal environment on teacher attitudes. (Students involved in this study filled out a form indicating their level of comfort five times daily. This data will be analyzed in a separate report).

Recommendation No. 9

Future studies should be continued in order to determine if there is a comfort zone at which students do learn best.

Recommendation No. 10

Future research ought to be conducted to determine if, after an intensive period of physical activity, an ideal thermal environment shortens the time necessary for a return to usual classroom routine of the students.

APPENDICES

APPENDIX A

HOME CLASSROOM TEMPERATURE AND HUMIDITY RECORDINGS

	Time											
	0900		1000		1100		1200		1300		1400	1500
Date	T	H	T	H	T	H	T	H	T	H	T H	T H
Sept. 7	76	69	78	74	79	73	77	71	76	72	77 69	79 [illegible]
Sept. 8	74	68	76	71	77	69	78	68	71	71	71 74	78 77
Sept. 9	79	81	82	76	83	73	84	70	82	64	[illegible]	[illegible]
Sept.10	78	56	79	55	60	57	63	51	65	54	[illegible]	[illegible]
Sept.13	76	75	76	75	75	72	7[illegible]	70	7[illegible]	7[illegible]	[illegible]	[illegible]
Sept.14	76	65	76	68	77	70	77	70	77	71	77 69	76 70
Sept.15	62	53	73	57	74	55	76	55	77	50	77 [illegible]	77 [illegible]
Sept.16	69	61	70	62	70	62	70	63	70	64	70 60	70 [illegible]
Sept.17	73	68	73	62	75	62	75	[illegible]	76	62	77 [illegible]	76 55
Sept.20	75	71	74	69	74	69	75	[illegible]	75	65	75 [illegible]	77 65
Sept.21	73	74	72	68	72	64	71	[illegible]	72	62	75 [illegible]	72 47
Sept.22	72	55	74	54	75	54	77	[illegible]	[illegible]	52	77 [illegible]	75 [illegible]
Sept.23	69	50	70	52	73	53	76	[illegible]	76	[illegible]	[illegible]	[illegible]
Sept.24	84	37	85	37	86	37	86	37	86	36	86 37	86 37
Sept.27	72	48	74	47	75	46	76	46	76	47	77 [illegible]	78 47
Sept.28	78	55	77	58	79	58	82	[illegible]	[illegible]	55	[illegible]	[illegible]
Sept.29	76	56	[illegible]	63	81	61	[illegible]	[illegible]	[illegible]	59	[illegible]	[illegible]
Sept.30	75	55	75	56	74	56	74	52	74	50	74 [illegible]	74 56
Oct. 1	75	44	76	49	78	49	[illegible]	45	[illegible]	41	84 47	84 [illegible]
Oct. 4	78	44	82	41	80	41	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct. 5	78	40	81	38	82	38	[illegible]	40	[illegible]	44	86 [illegible]	[illegible]
Oct. 6	75	43	78	44	74	46	76	48	74	45	[illegible]	80 42
Oct. 7	77	38	79	41	82	38	[illegible]	37	[illegible]	33	81 [illegible]	79 [illegible]
Oct. 8	78	35	79	37	81	37	[illegible]	36	[illegible]	32	[illegible]	[illegible]
Oct. 11	80	33	82	34	83	30	85	29	[illegible]	24	[illegible]	[illegible]
Oct. 12	77	32	78	30	80	29	82	28	[illegible]	27	[illegible]	[illegible]
Oct. 13	77	33	80	31	81	30	84	30	[illegible]	30	[illegible]	[illegible]
Oct. 14	78	44	81	49	79	51	78	54	[illegible]	56	[illegible]	[illegible]
Oct. 15	82	50	80	54	80	56	82	58	85	57	[illegible]	[illegible]
Oct. 18	82	56	85	55	88	51	90	46	91	43	92 41	91 39
Oct. 19	79	52	79	56	80	57	79	57	79	58	78 62	78 61
Oct. 20	80	54	78	54	78	54	78	53	78	51	77 54	76 55
Oct. 21	78	51	79	50	78	48	78	47	77	47	76 51	76 52
Oct. 25	75	36	84	36	88	36	89	38	90	37	91 39	91 40
Oct. 26	79	35	86	36	92	34	88	34	86	31	87 37	85 38
Oct. 27	82	34	87	33	90	31	91	33	91	32	91 31	90 29

APPENDIX A (Continued)

Date	Time 0900 T	H	1000 T	H	1100 T	H	1200 T	H	1300 T	H	1400 T	H	1500 T	H
Oct. 28	78	29	84	30	90	27	91	27	91	22	91	24	91	25
Oct. 29	78	26	80	27	84	27	87	25	86	25	85	28	85	30
Nov. 1	78	31	83	30	89	25	92	23	90	21	91	22	87	21
Nov. 2	81	32	86	35	88	35	90	35	92	34	88	34	88	32
Nov. 3	81	36	82	37	84	38	83	38	84	38	84	40	86	40
Nov. 4	78	31	82	30	85	26	88	26	88	24	88	25	89	26
Nov. 5	76	31	81	32	85	33	86	38	88	41	89	43	88	44

APPENDIX B

SPELLING LESSONS

FIRST WEEK

1. alley
2. choose
3. naked
4. stare
5. escape
6. happiest
7. terms
8. swear
9. aware
10. today's
11. gentle
12. stunts
13. abuse
14. population
15. remembered
16. damage
17. threw
18. pity
19. except
20. reduce

SECOND WEEK

1. device
2. seek
3. there's
4. sleeves
5. blankets
6. rare
7. suppose
8. hurried
9. decide
10. crawl
11. treatment
12. degree
13. broad
14. causes
15. sole
16. proof
17. nickel
18. depth
19. insects
20. compare

THIRD WEEK

1. mistaken
2. consist
3. fetch
4. lease
5. moss
6. artist
7. clerks
8. folk
9. amusing
10. adjust
11. impress
12. mighty
13. conduct
15. hither
16. cottage
17. bridge
18. double
19. burnt
20. campus

FOURTH WEEK

1. mayor
2. worship
3. average
4. headquarter
5. watermelon
6. checkers
7. canal
8. cliff
9. empire
10. catalog
11. peanut
12. noticed
13. abroad
14. tunnel
15. men's
16. fare
17. quarter
18. expected
19. palace
20. oversight

FIFTH WEEK

1. furnish
2. chamber
3. regards
4. wages
5. admire
6. eager
7. beyond
8. chased
9. passage
10. written
11. pertaining
12. barrel
13. distant
14. complain
15. weigh
16. contact
17. steer
18. zebra
19. insult
20. comment

SIXTH WEEK

1. grandma's
2. soul
3. fitted
4. shone
5. convention
6. slight
7. salad
8. boiler
9. investment
10. how's
11. burst
12. habits
13. rotten
14. chalk
15. addressed
16. knit
17. captain
18. pumpkin
19. verses
20. management

SEVENTH WEEK

1. potato
2. brake
3. beautiful
4. wherever
5. dropped
6. requested
7. allow
8. Bible
9. really
10. agents
11. afterward
12. organ
13. comply
14. lying
15. restless
16. eighth
17. gotten
18. bleeding
19. angel
20. one-half

EIGHTH WEEK

1. figure
2. action
3. signal
4. presents
5. breaking
6. problem
7. colored
8. captured
9. largely
10. shade
11. forwarded
12. factor
13. scrap
14. liberty
15. bathe
16. sane
17. locate
18. journey
19. freshman
20. sentence

NINTH WEEK

1. chores
2. useless
3. strain
4. including
5. growth
6. entertain
7. tracer
8. officers
9. confess
10. arrived
11. disaster
12. here's
13. wisdom
14. union
15. collar
16. needle
17. pleasure
18. telephone
19. crush
20. bookkeeping

APPENDIX C

HANDWRITING

FOUR WEEK PROGRAM

September 13 - 17

Motivation and Scale Evaluation Characteristics of Letters

September 20 - 24

Form and Speed

September 27 - October 1

Slant and Spacing

October 4 - 8

Size - Line Quality - Re-evaluation

The following paragraph was used for evaluation:

I live in America. It is good to live where you have freedom to work and play. As an American, I support my country and what it stands for.

APPENDIX D

ACCURACY

September 7, 1965

The Monroe Adding Machine Company representative gave a twenty minute demonstration to both the experimental and control groups. The demonstration was a lesson in the proper use of a ten key hand operated adding machine.

September 9, 1965

Add

84	22	79	23	33	69	67	57
78	53	32	75	31	91	16	65
92	36	63	69	32	75	63	79
43	59	46	27	28	18	58	59
				37	53	75	61
76	94	59	45	29	61	80	67
96	59	60	38	42	79	39	50
74	18	38	63	48	89	79	91
59	97	41	50	63	32	42	28
85	34	49	37	29	16	24	53

Subtract

81	113	417	871	723	700	4000
-37	87	283	236	109	204	1275
63	146	626	600	824	562	2206
29	29	491	417	297	129	997

Watch the signs:

17 + 4 =	32 + 9 =	87 - 5 =	65 - 6 =
24 + 7 =	59 - 3 =	76 + 6 =	44 + 9 =
39 - 5 =	38 + 8 =	85 - 23 =	96 - 33 =

September 14, 1965

1-	62	327	658	573	947	213
	79	409	356	853	291	1164
	18	126	622	895	926	643
	25	543	174	427	291	928
	46	188	429	247	803	2675

2-	27	265	501	337	135	7829
	19	547	734	384	393	324
	83	596	498	433	235	429
	60	285	161	675	869	2074
	56	639	732	654	318	1168

3- 87 - 5 = 36 - [illegible] = [illegible] - 3 = 68 - 4 =

4- 60 - 6 = 90 - 5 = 30 - 7 = 70 - [illegible] =

5- 52 - 9 = 71 - 4 = 35 - [illegible] = 84 - 6 =

6-	91	679	145	356	456	1731	2436
	-73	337	-92	-357	-463	-497	-2252

7-	58	471	126	660	332	5304	1292
	-46	-148	-79	-321	-257	-2388	-524

September 16, 1965

Subtract:

1-	4833	2919	6534	73146	70000
	1246	2437	2635	57457	42398
2-	1655	5000	4288	16270	35843
	687	2465	1535	8628	17987
3-	5018	7188	4000	91421	14932
	4568	3759	2152	72394	6205

Add

1-	334	532	376	275	468
	286	378	817	552	354
	412	466	343	299	968
	293	576	464	507	354
2-	173	343	897	303	128
	216	850	923	417	694
	835	979	654	242	149
	637	468	149	603	744
3-	713	132	534	486	274
	258	275	176	146	527
	524	807	665	694	993
	465	355	436	283	306

September 21, 1965

Find the missing answers

34 +S 57	S +46 99	28 +94 ___	64 +S 142	S +72 140	95 -56 ___	A -35 40
76 -S 37	A -15 58	62 -S 19	S +39 103	41 -S 27	55 +S 144	73 +57 ___
A -97 125	611 S 926	S +354 883	295 +S 769	S +576 695	587 +S 979	
915 -S 692	A -284 543	582 -379 ___	973 -S 827	A -165 509		
S +415 837	881 +367 ___	517 -S 155	S +234 917	134 +S 461		

September 23, 1965

Subtract

1-	81	113	417	871	723	700	4000
	-37	87	283	236	189	234	1275
2-	63	146	626	600	814	562	2206
	29	29	491	417	297	129	997

Add

3-	3536	4715	1485	4382	3065
	4658	7863	8276	6644	656
	1943	935	6533	3600	274
	2206	1487	773	3579	3705

Subtract

4-	5402	5325	60001	90258	4367
	3865	4695	28423	63699	2369
5-	7674	43817	60000	259	956
	4837	16325	39753	239	481

Add

6-	146	845	156	968	376
	672	989	692	171	509
	759	417	526	420	482
	283	983	384	407	571
	314	755	627	819	248

September 28, 1965

Add

1-

628	683	296	793	957
499	807	534	455	036
714	965	887	677	788
362	545	128	907	449
924	238	312	826	551
534	725	493	141	467
796	754	341	122	301
818	459	457	273	388

Subtract

2-

5689	8793	8761	4080	5549
3462	2649	1896	3245	4796
3306	3478	7204	6458	4000
1737	1219	5244	5569	2496

Find the missing numbers

+12 = 26	18 + ___ = 24	+17 = 35	-15 = 23	-19 = 36	-14 = 31
22 + ___ = 39	33 + ___ = 65	28 + ___ = 54	-28 = 67		

September 30, 1965

Subtract

1-	35488	58194	43317	80000	32443
	15254	25475	24654	3086	22578
2-	62385	30000	68230	91554	70002
	47426	14175	23631	23476	49257

Add

3-	334	532	376	275	468
	286	378	817	552	154
	412	466	343	299	968
	293	576	464	507	354
4-	173	343	[illegible]	301	128
	216	850	[illegible]	417	694
	835	979	[illegible]	241	149
	637	468	149	603	744

Subtract

5-	86565	50923	73873	66925	8060
	67078	33653	38986	19389	7935

Add

6-	713	132	534	486	176
	258	275	176	146	527
	524	807	665	894	993
	465	355	436	283	306

October 5, 1965

Subtract

5698	9795	7003	5864	6542
3646	9539	3835	4368	965
3817	9325	5368	6000	3238
3466	4657	928	5265	2899

Add

509	193	131	350	3689
86	741	857	29	545
221	436	44	43	1331
74	86	52	299	177
122	79	403	490	1485
637	298	135	427	3642

Subtract

9182	4950	7784	5562	5000
5898	2866	797	3583	2517
5546	9221	7692	6785	3000
1448	234	7424	3135	1353
8003	8926	$52.12	$60.56	$29.61
2987	8171	37.23	4.46	19.79

October 7, 1965

196	232	466	611	734	615
+147	+561	+123	+436	+861	+720
-205	-344	-377	-410	-943	-306

Subtract

2869.45	6000.00	1200.50	6151.55	8000.00
984.68	1572.43	489.56	4121.69	7639.74
67148	29784	25394	14570	62700
25025	16995	16875	13868	28469
12547	70034	80000	85136	33959
10868	56229	40259	53854	17066

Add

2217	3007	1589	2669	3249
482	8757	1622	874	456
3453	3686	963	4357	4477
2248	2850	747	2396	1576
574	3469	1944	253	1032
1032	3240	2516	3702	9976
281	5385	967	3589	434
9691	764	3945	1299	6447
569	2395	657	1865	668
7453	345	1438	2599	8089

October 12, 1965

1-	146	433	732	611	710	613
	+232	+610	+249	+499	+135	+478
	-104	-573	-467	-782	-463	- 10

2- 19.6-14.7= 1.82-44= 454-274=

3- 500.00-375.39= 52.8-44.2= 5.13-2.50=

4- 79.0-25.5= 6.54-.58= 640.00-494.26=

5-	16.18	36.75	14.52	56.38	32.47
	49.00	79.77	9.89	7.54	51.26
	56.86	74.43	33.55	14.57	67.94
	46.05	5.63	25.38	76.54	31.04
	47.37	21.34	16.66	54.44	36.39

6-	4216	5572	4353	8428	7413
	-2384	-4853	-1499	-4369	-2436

7-	3122	5000	8528	8387	6271
	-1999	-2327	-2662	-1597	-5795

8-	149	673	833	927	100
	+633	+542	+651	+433	+500
	-123	-411	-504	-344	-146

October 14, 1965

1-	432	545	984	412	376
	+698	+499	+236	+378	+665
	-123	-162	-650	-111	-407
2-	2407	3586	1946	5687	9613
	-135	-803	-217	-693	-450
3-	7593	2018	6874	3502	5280
	-5259	-1893	-1974	-467	-1265
4-	1652	6478	1549	3675	14527
	789	749	429	7977	98902
	2203	4375	6984	7443	33355
	937	343	262	563	25382
	756	310	677	2134	16266
5-	2217	3007	1589	26693	32492
	482	8757	1622	87464	45629
	3453	3686	968	43571	44727
	2248	2850	747	23936	15760
	574	3469	1944	23545	10323
6-	659	454	849	214	873
	+322	+949	+326	+783	+565
	-233	-261	-506	-997	-707

October 19, 1965

436 +614 -406	598 +266 -189	711 +636 -366	833 +467 -674	1054 +2101 -1347
433 688 768 943 176	544 787 138 494 886	989 134 464 555 198	673 445 898 343 722	646 133 748 626 1044
349 +688 -404	986 +737 -198	683 +405 -176	1055 +9033 -8853	1193 +8048 -6854
565 492 874 435 712	939 474 532 163 764	714 826 +147 -613	613 432 +713 -414	933 621 +505 -389
13924 -8697	22183 -15613	46054 28669	51122 -7935	
58334 51385	35947 8494	14200 5234	59182 35874	

October 21, 1965

431	724	827	4513	9218
420	904	684	9754	2370
813	861	758	267	567
196	354	866	755	9068
618	357	9419	4150	1352
+896	+883	+7656	+5241	+6135
-565	-343	-6073	-6112	- 404
1148	5085	3856	3621	242
9386	8375	7867	6787	732
9989	7668	8784	4278	6
4579	9737	4979	6379	36
9068	755	101	1010	21
550	2734	8357	98765	12381
-431	-742	-3365	-86444	-3582
976	12455	985	32033	6318
+372	+8888	+632	+9999	+3475
-133	-7676	-100	-8686	-1123
6534	7998	8967	75442	8895
-4667	-2722	-6822	-65578	-4845

October 26, 1965

436 +676 -143	9062 +1783 -4242	7677 +1364 -1232	6832 +4232 - 838	7063 +6984 - 615
1323 6744 8723 6832	9324 1363 4164 7464	8613 4244 7361 8208	9499 8613 4268 1003	7172 6343 145 6876
7364 -1342	8601 -7698	4345 -1598	4368 -2232	6849 -5909
444 +686 -135	561 434 +681 -323	732 +868 -568	7098 -1659	8989 -6666
793 468 735 904	8436 9365 8060 4323	6986 4368 5032 7377	4341 9062 7362 4089	7777 6812 3276 4489
4689 -1368	56898 -23689	46861 -17893	7383 -6869	71012 -66130

October 28, 1965

1-	7064 -3285	6045 -1587	9056 -7689	8093 -3897	6045 -2796
2-	6010 -3784	8010 -5491	7004 -2929	9006 -5307	6007 -4419
3-	4375 6098 7254 2109 8175	1264 4796 2798 3887 7987	2989 5685 2507 6706 2853	$81.75 .59 6.43 79.87 21.09	3523 2501 2684 4999 5080
4-	974 + 1002	+296 303	58 + 855	499 + 1007	-1423 4817
5-	1264 +4796 -1030	2798 +3887 -4213	2989 +5685 -6847	2507 +6706 -2931	2853 + 88 -1492
6-	13864 +62932 -50673	84350 +14683 -63604	76132 +13683 -89815	11124 +88686 -99810	10321 +93201 -62163

November 2, 1965

Watch the signs

413 + 836	511 + 1404	673 + 935	781 - 404	966 - 610
2653 -895	942 -573	7437 -6255	4638 -2846	92761 -65970
3742 8631 1475 - 847	4045 8628 3791 -5070	2493 384 4275 - 36	6802 2213 3729 -4987	4975 6105 4398 -9865
57390 -34857	20793 -17621	23653 -1217	18349 -2673	34765 -12786
32596 +8371	46728 +1596	21479 +8521	64047 -38659	68400 -62534
71524 37229 36272 60020	2730 6002 2791 9703	9283 6513 9286 9064	6793 6535 4786 8365	1625 5923 4876 3774

November 4, 1965

1463 +6302 -4303	1684 +4971 -1309	7613 +4414 -6898	4748 +1070 -681	325 +146 -109
9083 -6135	7365 -4973	3892 -2475	5183 -3486	49580 -7321
7321 583 4932	6748 7659 85	325 9685 3765	5963 839 7532	23750 4825 673
468 -279 +684	8500 -685 +135	7895 -854 +968	2005 -347 +1968	8967 -3425 +5542
4132 321 213 121	875 476 329 8720	1234 3412 2615 3172	8977 4675 1352 683	4563 2518 224 468
2653 -895	942 -573	7623 +492	4638 -2846 +1792	9276 -6597 +1638

APPENDIX E

MATHEMATICS

September 8, 1965

Addition Facts

You learned 100 addition facts. You should know the easy addition facts. Let us see if you know 36 of the more difficult addition facts.

Write the answers for these addition sentences.

8 + 4 = ___ 4 + 8 = ___	7 + 3 = ___ 3 + 7 = ___	+ 5 = ___ 5 + 6 = ___	7 + 5 = ___ 5 + 7 = ___
8 + 3 = ___ 3 + 8 = ___	9 + 3 = ___ 3 + 9 = ___	7 + 4 = ___ 4 + 7 = ___	8 + 6 = ___ 6 + 8 = ___
8 + 7 = ___ 7 + 8 = ___	7 + 6 = ___ 6 + 7 = ___	8 + 5 = ___ 5 + 8 = ___	9 + 4 = ___ 4 + 9 = ___
9 + 5 = ___ 5 + 9 = ___	9 + 6 = ___ 6 + 9 = ___	9 + 7 = ___ 7 + 9 = ___	9 + 8 = ___ 8 + 9 = ___
6 + 6 = ___	7 + 7 = ___	8 + 8 = ___	9 + 9 = ___

67 addend
+22 addend
89 sum

In the example, the numbers _____ and _____ are addends.

When two or more numbers are added, the answer is called the _____.

Circle the sign for addition: + - x ÷

Write the addends on the first line and the sum on the second line.

1. Henry sold 42 papers on Monday and 45 on Tuesday. How many newspapers did he sell in two days?

_____ _____

2. Dale mowed lawns for neighbors. He earned $32 during June and $43 during July. How much did he earn during June and July?

_____ _____

September 8, 1965

Subtraction Facts

You learned 100 subtraction facts. You should know the easy subtraction facts. Let us see if you know 36 of the more difficult facts.

Write the answers for these subtraction sequences.

11 - 2 = ___	11 - 3 = ___	11 - 4 = ___	11 - 5 = ___
11 - 9 = ___	11 - 8 = ___	11 - 7 = ___	11 - 6 = ___
12 - 3 = ___	12 - 4 = ___	12 - 5 = ___	13 - 4 = ___
12 - 9 = ___	12 - 8 = ___	12 - 7 = ___	13 - 9 = ___
13 - 5 = ___	13 - 6 = ___	14 - 5 = ___	14 - 6 = ___
13 - 8 = ___	13 - 7 = ___	14 - 9 = ___	14 - 8 = ___
15 - 6 = ___	15 - 7 = ___	16 - 7 = ___	17 - 8 = ___
15 - 9 = ___	15 - 8 = ___	16 - 9 = ___	17 - 9 = ___
12 - 6 = ___	14 - 7 = ___	16 - 8 = ___	18 - 9 = ___

847 minuend
-213 subtrahend
634 remainder

In the example, the number _____ is the minuend; the number _____ is the subtrahend.

When one number is taken from another number, we call the answer the _____.

Circle the sign for subtraction: + - x ÷

Write the minuend on the first line, the subtrahend on the second line, and the remainder on the third line.

1. Charles earned 75 cents during the first week of his summer vacation and 50 cents the second week. How much more did he earn the first week than the second?

_____ _____ _____

2. Frank visited the navy yard. Yesterday he saw 36 ships and today he saw 57 ships. How many more ships did Frank see today than yesterday?

_____ _____ _____

September 10, 1965

Addition of Tens and Ones

54 = 5 tens 4 ones
43 = 4 tens 3 ones
97 = 9 tens 7 ones

or

90
97 = 90 + 7 = 97

Add the ones.
4 + 3 = 7.
Add the tens.
5 + 4 = 9.

Write the addition sentence for the example.

_____

Put in the missing numbers. Write the sums.

63 = ____ tens ____ ones
36 = ____ tens ____ ones

74 = ____ tens ____ ones
30 = ____ tens ____ ones

Add.

48	86	73	82	64	53
31	53	45	24	14	32
63	95	60	55	73	84
74	80	47	44	65	70

Add ones to tens and ones.

74 = 7 tens 4 ones
5 = 0 tens 5 ones
79 = 7 tens 9 ones

or

70 + 9 = 79

Add the ones.
4 + 5 = 9.
Add the tens.
7 + 0 = 7.

15	33	28	76	54	83
4	5	1	2	3	6
65	2	11	3	91	5
3	73	8	24	4	42

September 10, 1965

Column Addition

Add from the top down.
To check, add from the bottom up.

5				
2	7	Think: 7, 14,22,23.	42	Column one.
7	14		31	Think: 2,3,5,8.
8	22		52	Column two.
1	23		63	Think: 4,7,12,18.
23		The sum is 23.	188	The sum is 188.

Add and check.

3	1	6	9	7	8
8	7	0	1	4	9
5	2	5	3	0	4
4	9	8	2	6	0
3	5	9	4	9	6
6	8	1	2	1	5
2	0	6	5	4	2
1	7	7	8	0	9
4	3	0	3	7	8
21	45	57	72	55	43
32	81	90	83	80	62
50	63	31	60	71	21
76	20	41	94	93	90

Add across from left to right. Check from right to left.

4 + 1 + 3 + 2 = ____	6 + 1 + 3 + 4 = ____
4 + 5 + 3 + 6 = ____	7 + 0 + 8 + 1 = ____
7 + 8 + 2 + 3 = ____	7 + 8 + 1 + 9 = ____
5 + 2 + 0 + 6 = ____	9 + 0 + 7 + 5 = ____
2 + 8 + 9 + 6 = ____	8 + 4 + 7 + 6 = ____

September 13, 1965

Addition with Carrying

1. Mr. Brown planted some trees in his orchard. He planted 55 peach trees, 76 apple trees, and 24 pear trees. How many trees did he plant?

_____

2. Mr. Brown counted the apple trees in the first three rows of his orchard. He counted 38 trees in the first row, 27 trees in the second row, and 46 trees in the third row. How many trees did he count?

_____

3. Mr. Brown then counted the peach trees. He counted 64 trees in the first row, 75 trees in the second row, and 59 trees in the third row. How many peach trees did Mr. Brown count?

_____

Add and check.

68	77	86	27	39	18
89	76	39	69	45	36
56	69	76	15	28	27
53	25	20	88	87	97
74	82	17	34	64	35
66	49	68	50	73	70
6	80	65	90	88	7
81	6	75	48	60	57
35	44	2	5	4	70

September 13, 1965

A Bookstore

Mrs. Taylor sold 92 books from a shelf containing 148 book. How many books remained on the shelf?

_____

148 books Subtract the ones.
-92 books Subtract the tens.
56 books 5 tens and 6 ones = _____

1. Mrs. Taylor sold 48 pencils from a box containing 128 pencils. How many pencils remained to be sold?

_____

2. Mrs. Taylor had 115 packs of paper and sold 54 packs. How many packs of paper were left?

_____

3. Mrs. Taylor bought 135 new books on the first day of the month. During the month she sold 95 of them. How many books did she have left?

_____

4. Mrs. Taylor had 124 birthday cards in her store. Mary and her classmates bought 31 of them. How many birthday cards were left?

_____

5. The third grade class decided to buy adventure books for the library. They found 129 adventure books at the bookstore and bought 36 of them. How many adventure books remained in the store?

_____

September 15, 1965

Adding Three-Place Numbers

	hundreds	tens	ones
752 =	7	5	2
436 =	4	3	6
1188 =	11	8	8

1100 + 80 + 8 = 1188

Add the ones.
2 + 6 = 8.
Add the tens.
5 + 3 = 8.
Add the hundreds.
7 + 4 = 11.

Write the addition sentence for the example.

_____

Put in the missing numbers.

	hundreds	tens	ones
645			
634			

Write the sums.

	hundreds	tens	ones
317			
821			

Write the sums for these examples.

45	61	30	45	62	84
61	84	95	80	47	21
10	23	44	33	60	73
421	624	704	345	210	
134	350	154	421	367	
541	113	131	213	312	
451	652	840	741	524	
406	314	126	541	351	
341	723	233	215	502	

September 15, 1965

Problems

1. In Mr. Arnold's store there were 63 bicycles. Because of the Christmas holidays, he bought 36 more. How many bicycles did he have then?

_____ number of bicycles he had.

_____ number of bicycles he bought.

_____ number of bicycles he had then.

2. There are 284 boys and 315 girls in the Franklin School. How many pupils are there in the Franklin School?

_____ boys in the Franklin School.

_____ girls in the Franklin School.

_____ pupils in the Franklin School.

3. John spent 20 cents for a coloring book, 12 cents for crayons, and 25 cents for a pen. How much did John spend?

_____ cost of the book.

_____ cost of the crayons.

_____ cost of the pen.

_____ total cost.

4. Lt. Hess flew 424 miles with his Army airplane. Capt. Day flew 450 miles; and Lt. Col. Glenn flew 323 miles. How many miles did the three officers fly?

_____ miles Lt. Hess flew.

_____ miles Capt. Day flew.

_____ miles Lt. Col. Glenn flew.

_____ miles the three officers flew.

September 17, 1965

United States Money

$3.37 .21 6.41 $9.99	Dollars	Cents 25 $16.25		$3.46 -1.23 $2.23

Be sure to put the dollar sign and cents point in each answer.

Add.

$3.45 4.34	$5.61 5.36	$7.26 .72	$6.20 6.45	$8.50 .40
$2.31 1.25 4.32	$4.26 2.42 5.11	$6.34 3.15 5.50	$7.30 4.23 4.03	$9.20 8.00 2.45
$7.64 .12 4.20	$5.00 6.74 .20	$6.03 .83 8.10	$9.24 .51 7.00	$6.21 3.10 .45

Subtract.

$9.84 8.23	$1.75 .92	$6.79 4.53	$8.64 .33	$9.00 4.00
$10.00 6.00	$12.35 8.21	$15.84 7.32	$14.75 9.60	$11.54 5.24
$18.07 9.07	$12.84 7.00	$16.27 9.27	$10.98 3.90	$18.87 9.35

September 17, 1965

Money Problems

Be sure to put the dollar sign and the cents point in the answer. Show your work.

1. Henry bought a baseball outfit for $9.25 and a football for $5.10. How much money did he spend?

_____

2. George has $9.75. He wants to buy a baseball and a bat that will cost $3.75. If he buys the baseball and bat, how much money will he have left?

_____

3. Alice bought a dress for $4.25, a pair of shoes for $6.00, and a sweater for $5.20. Alice spent _____.

4. Jack worked three days. The first day he earned $4.50, the second day $5.00, and the third day $6.25. How much did Jack earn in three days?

_____

5. The pupils in Helen's class have a saving's plan. The first week they saved $3.54, the second week $4.10, and the third week $5.35. The girls saved _____ in three weeks.

6. Mr. Davis earned $59.75 in one week. He paid $22.50 for food. Mr. Davis had _____ left.

September 22, 1965

Missing Numerals

Put the missing numerals in each example.

34 + ___ 57	+46 99	23 +94 ___	64 + ___ 142	+72 140
95 -56 ___	-35 46	76 - ___ 37	-15 58	62 - ___ 19
+39 ___	41 - ___ ___	55 + ___ ___	73 +57 ___	-97 ___
611 + ___ 926	+354 883	295 + ___ 769	+576 695	587 + ___ 979
915 - ___ 692	-284 543	582 -379 ___	973 - ___ 827	-185 509
+415 807	881 -367 ___	517 - ___ 155	+234 917	134 + ___ 461

September 24, 1965

Dollars and Cents

The dollar sign ($) and the cents point (.) are used in writing dollars and cents. The name for the "cents point" is "decimal point." It is used to show parts of a dollar.

Add.

$16.45
9.70
$26.15

Add the cents first, the dimes next, and then the dollars. Always keep the decimal points directly under each other in adding money.

$5.65 1.25	$2.67 8.52	$2.44 7.56	$8.53 5.49	$9.46 6.72
$17.80 6.09	$26.15 8.90	$18.05 7.40	$44.65 8.77	$16.30 5.50
$12.75 26.29	$34.45 15.82	$16.80 47.33	$18.03 4.07	$17.00 14.00

Subtract.

$14.25
6.12
$ 8.13

Subtract the cents first, the dimes next, and then the dollars. Write the dollar sign and the cents point in each answer.

$5.25 2.10	$6.40 3.20	$4.68 2.54	$9.50 4.00	$8.66 6.46
$12.75 4.25	$11.60 6.40	$13.78 7.50	$12.70 5.70	$17.80 9.30
$1.25 .25	$1.50 .70	$1.45 .82	$1.00 .60	$1.70 .90

September 24, 1965

Buying and Selling

1. Pete went on a two-day trip with his father. The first day he spent $5.35 and the second day $3.70. How much did Pete spend on the trip?

_____

2. Lois spent $9.25 for a pair of shoes and $3.75 for a hat. The shoes and hat cost

_____.

3. Russell earned $14.80 the first week in July and $7.50 the second week. He earned _____ more the first week than the second.

4. Connie had $10.75. She spent $9.50 for a puppy. How much money did she have left?

_____

5. Mr. Pharo received $8.25 from the sale of black raspberries and $6.75 from the sale of red raspberries. He received _____ from the sale of the berries.

6. Lewis wants to save $27.50 for Christmas. He has already saved $9.25. How much more must he save?

_____

7. Charles wants to buy a pair of ice skates that cost $8.25. He has saved $4.65. How much more does Charles need to save to pay for the skates?

_____

September 27, 1965

The Missing Number

In the examples on this page, the N stands for a missing number.

N + 3 = 10	In this number sentence N stands for the missing number.
N = 10 - 3 N = 7	To find N, we subtract. 10 - 3 = 7. The missing number is 7.
N - 5 = 4 N = 5 + 4 N = 9	To find N in this example, we add. 5 + 4 = 9. The missing number is 9.

N + 4 = 7
N =

N + 5 = 9
N =

N + 3 = 5
N =

N - 3 = 6
N =

N - 2 = 7
N =

N - 6 = 3
N =

5 + N = 8
N =

6 + N = 10
N =

7 + N = 12
N =

N - 4 = 9
N =

N - 5 = 7
N =

N - 8 = 7
N =

N + 6 = 14
N =

N - 9 = 8
N =

8 + n = 15
N =

12 + N = 16
N =

22 - N = 17
N =

N - 9 = 11
N =

N + 5 = 28
N =

N - 3 = 22
N =

27 + N = 34
N =

N - 9 = 35
N =

N - 7 = 43
N =

38 + N = 50
N =

September 27, 1965

Problems

Use N in writing the number sentences to solve these problems.

1. There were 34 pupils in a class. Sixteen of them were boys. How many girls were in the class?

Work Space
N + 16 = 34
N =

2. George had 65¢. His father gave him 30¢. George now has _____ cents.

65 + 30 = N
N =

3. Ray had 36 marbles in his bag. How many marbles did Ray have after he bought 43 more marbles?

4. The fifth grade bought 14 new books for the room library. There are now 72 books in the library. The library had _____ books before the new books were bought.

5. There are 68 desks in the art room and the music room. In the art room there are 32 desks. There are _____ desks in the music room.

6. The fifth-grade pupils visited the museum. Out of a class of 34 pupils, 8 did not go to the museum. How many pupils went to the museum?

7. Sam sold 35 magazines one day. The next day he sold 23 magazines. Sam sold _____ magazines in all.

September 29, 1965

Regrouping Twice in Subtraction

		hundreds	tens	ones		Regrouped hundreds	tens	ones
764	=	7	6	4	=	6	15	14
578	=	5	7	8	=	5	7	8
186						1	8	6 or
						100	+ 80	+ 6 = 186

By regrouping 764 into 6 hundreds, 15 tens, and 14 ones, you can subtract 8 ones from 14 ones and 7 tens from 15 tens.

Write an example. Solve it. Regroup if necessary.

	hundreds	tens	ones	Regroup hundreds	tens	ones
=						
=						

Solve these examples.

563 178	816 347	620 258	327 267
1224 418	1736 908	1563 786	1500 327
2824 1536	9563 5486	7985 3995	8004 5612
$9.50 5.73	$18.23 9.42	$82.36 68.48	$75.00 60.76

September 29, 1965

Number Sentences

In the examples on this page, the N stands for the missing number.

N + 24 = 49
N = 49 - 24
N = 25

To find N, we subtract.
49 - 24 = 25.
The missing number is 25.

N - 31 = 42
N = 42 + 31
N = 73

To find N in this example, we add.
42 + 31 = 73.
The missing number is 73.

N + 12 = 26

N + 18 = 24

N + 17 = 35

N - 15 = 23

N - 19 = 36

N - 14 = 31

22 + N = 39

33 + N = 65

28 + N = 54

N - 28 = 67

N - 34 = 72

N - 45 = 87

N + 56 = 71

October 1, 1965

Missing Numerals

Put the missing numerals in each example.

34 + ___	+46	28 +94	64 + ___	+72
95 -56	-35	76 - ___	-15	62 - ___
+39 103				

Nickel	Dime	Quarter	Half Dollar
5¢	10¢	25¢	50¢

1 nickel = ___ cents	1 dime = ___ cents
1 dime = ___ nickels	1 quarter = ___ cents
1 dollar = ___ cents	1 quarter = ___ nickels
1 dollar = ___ quarters	1 dollar = ___ dimes
1/2 dollar = ___ quarters	1/2 dollar = ___ cents
50 cents = ___ quarters	50 cents = ___ dimes
70 cents = ___ dimes	10 cents = ___ dime
300 cents = ___ dollars	100 cents = ___ dollar
4 quarters = ___ dollar	8 dimes = ___ cents
40 cents = ___ nickels	8 quarters = ___ dollars

$ 2.48 = ___ dollars	___ quarter	___ dimes	___ cents
$ 4.98 = ___ dollars	___ quarters	___ dimes	___ cents
$10.48 = ___ dollars	___ quarter	___ dimes	___ cents
$18.74 = ___ dollars	___ half dollar	___ dimes	___ cents
$14.65 = ___ dollars	___ half dollar	___ dime	___ nickel

October 4, 1965

Multiplication with Carrying

	24	Multiply the ones. 3 X 4 = 12.
	24	Write the 2 in ones' place.
24	24	Carry the 1 ten to tens' place.
X3	24	Multiply the tens. 3 X 2 = 6.
72	72	The 6 tens plus the 1 ten carried equal 7 tens.
		Write 7 in tens' place.
		The product is 72.

The multiplication sentence for this example is 3 X 24 = 72.

The tens and ones can also be multiplied in two separate steps.

3 X 24 = (3X4) + (3X20) = 12 + 60 = 72.

Multiply. Check your work carefully.

26	47	28	35	19	18
5	2	3	4	3	2
79	57	36	19	58	14
2	5	3	4	2	3
45	44	48	37	39	46
2	3	5	3	4	2
67	68	59	56	27	29
4	3	4	5	2	5

Put the missing numerals in each of these sentences.

4 X 38 = (4 X __) + (4 X __) = ___ + ___ = ___

3 X 45 = (3 X __) + (3 X __) = ___ + ___ = ___

2 X 96 = (2 X __) + (2 X __) = ___ + ___ = ___

5 X 67 = (5 X __) + (5 X __) = ___ + ___ = ___

October 4, 1965

Problems

Write the multiplication sentences for these problems in the work space.

1. There are 14 boys on each of 4 teams in a small baseball league. How many boys belong to the league?

_____

2. In order to fit the boys properly with uniforms, each team owns 17 uniforms. The 4 teams own _____ uniforms.

3. At 49¢ each, what would 3 books cost Ann?

_____

4. Allen has a stamp book. If 36 stamps fill a page and he has 5 pages filled, how many stamps are in his book?

_____

5. There are 2 pints in 1 quart. How many pints are in 75 quarts?

_____

6. Charles bought 3 small airplanes. They cost 28¢ each Charles paid _____ cents for the airplane.

7. Wilson practices on his trumpet 45 minutes each day. How many minutes would he practice in 3 days?

_____

October 6, 1965

Subtracting with zeros

1-	300	500	700	900	400	506	307	480
	137	396	362	425	284	139	108	240
	300	500	800	700	$15.50	$26.00	$38.04	$18.00
	76	45	92	84	2.50	13.57	16.27	17.75

Subtract - Check the remainders

2-	800	600	600
	-135	246	236

Add

3-	511	643	431	623
	215	512	728	750
	193	388	648	738
	765	$4.25	$7.40	$3.06
	852	3.12	3.98	1.90
	504	2.98	2.79	2.28

Multiply

4-	36	25	35	64	53	61	40	27
	x4	x2	x3	x3	x5	x5	x3	x2

Divide

5- $2\overline{)24}$ $3\overline{)36}$ $3\overline{)96}$

October 8, 1965

Add

1-

511	643	431	623	546	374	450	376
215	512	728	750	176	206	325	425
193	388	468	738	245	262	604	134
623	611	113	612	122	107	292	651

$4.25	$7.40	$8.06	$5.14	300	765	$7.52	$4.11
3.12	3.98	1.90	8.52	445	852	8.33	6.27
2.98	2.79	2.28	6.36	609	504	6.34	4.35
				280	145	4.25	9.62

Subtract

2-

962	841	757	472	375	993	865	736
-643	-514	-238	-249	-149	-728	-426	-317

1157	1064	1238	1489
-743	-532	-727	-865

Find the Missing Number

43	62		42
-	+	+53	-
12	108	114	33

Multiply

35	47	52	44
x6	x6	x5	x4

October 11, 1965

Borrowing Twice in Subtraction

	Dollars		Dimes		Cents		Regrouped Dollars		Dimes		Cents
$6.72 =	6	.	7		2	=	5	.	16		12
-3.85 =	-3	.	8		5	=	3	.	8		5
$2.87							2	.	8		7

or
$2.87

By regrouping $6.72 into 5 dollars, 16 dimes, and 12 cents, you can subtract 5 cents from 12 cents and 8 dimes from 16 dimes.

Put the missing numbers in each group. Regroup if necessary. Write the answers.

	Dollars	Dimes	Cents	Dollars	Regroup Dimes	Cents
$5.23 =						
-3.77 =						

$5.48 =
-4.69 =

Subtract.

$7.18	$7.42	$8.25	$9.37
4.29	6.77	5.66	6.58
$37.23	$73.42	$47.27	$87.12
14.34	71.88	34.48	74.63
$54.76	$79.23	$65.34	$98.55
12.87	35.27	61.75	95.66

October 11, 1965

Buying and Selling

1. Mr. Davis spent $20.50 for a tire, $4.75 for an inner tube, and $2.75 for gasoline. He gave the dealer $30.00. How much change should he have received?

_____

2. Walter earned $33.75 in two months mowing lawns. He wants to buy a bicycle that costs $67.50. How much more money does he need?

_____

3. Mrs. Ranck has $9.42. She bought meat for $1.35, sugar for $1.05, juice for $1.36, and flour for $2.48. Her bill was _____. How much money did she have left?

_____

4. The pupils in Kay's fourth-grade room have a savings plan. The first week they saved $4.65, the second week $5.28, and the third week $2.95. How much did they save in three weeks?

_____

5. Dick weighs 67 pounds, Hugh weighs 74 pounds, and Don weighs 85 pounds. What is the total weight of the boys?

_____

6. Grace had $25.00. She bought a new dress for $9.95, new shoes for $6.50, and a new hat for $3.98. Grace had _____ left.

7. Mrs. Foose bought beef for $1.89, pork for 78 cents, and bacon for 52 cents. Mrs. Foose spent _____ for meat.

October 13, 1965

Regroup

	dollars	dimes	pennies		
$5.32 -3.79					
$7.11 -3.65					
$8.06 -4.39					
46 -17	77 -49	32 -23	84 -66	98 -79	
56 -48	70 -53	63 -38	60 57	95 -67	
278 -109	532 -366	401 -299	812 -631		

132 + N = 562
N =

Add

476 383 521	243 765 189	113 426 589	301 295 467	200 794 569	215 451 624
231 845 126	365 406 534	470 554 137	617 700 125	820 742 139	300 900 300

Multiply

43 x6	57 x3	94 x4	101 x 5	67 x5	43 x5	88 x8	73 x7

October 15, 1965

Watch the Zeros

Write the number sentences for these problems in the work space.

1. Lester sold 306 tickets at the baseball game. If 137 of them were adult tickets, how many tickets were sold to pupils?

_____

2. Earl and Carl together sold 1560 newspapers last week. Carl sold 724 of them. Earl sold _____ newspapers.

3. Mr. Lontz planted 700 trees in two orchards. In one orchard he planted 450 trees. How many trees did he plant in the other orchard?

_____

4. The Curtin School has 600 pupils and the Jackson School has 381 pupils. There are _____ more pupils in the Curtin School than in the Jackson School.

5. Sarah attended school 180 days last year. Grace attended 167 days. Grace attended _____ fewer days than Sarah.

6. Mr. Ross sold 905 gallons of gasoline. Mr. Jones sold 750 gallons. How many more gallons of gasoline did Mr. Ross sell than Mr. Jones?

_____

October 15, 1965

Zeros in Subtraction

	hundreds	tens	ones		Regrouped hundreds	tens	ones
600 =	6	0	0	=	5	9	10
236 =	2	3	6	=	2	3	6
364					3	6	4

or

300 + 60 + 4 = 364

By regrouping 600 into 5 hundreds, 9 tens, and 10 ones, you can subtract 6 ones from the 10 ones and 3 tens from the 9 tens.

Put the missing numbers in each example. Write the remainders.

	hundreds	tens	ones	Regroup hundreds	tens	ones
800 =						
135 =						

600 =
246 =

Subtract. Check the remainders.

300	500	700	900	400	506	307	480
137	396	362	425	284	139	108	240

300	500	800	700	600
76	45	92	84	33

$15.50	$26.00	$38.04	$24.50	$18.00
2.50	13.57	16.27	3.75	17.75

October 18, 1965

Regrouping in Addition

965 =	9 hundreds	6 tens	5 ones
486 =	4 hundreds	8 tens	6 ones
1451 =	13 hundreds	14 tens	11 ones
		or	
	14 hundreds	5 tens	1 one
		or	
		1400 + 50 + 1 = 1451	

You regroup the 11 ones into 1 ten and 1 one. Add the 1 ten to the 14 tens. 14 + 1 = 15.

You regroup the 15 tens into 1 hundred and 5 tens. Add the 1 hundred to the 13 hundreds.

Put the missing numbers in the example. Regroup the sum if necessary. Write the sum.

478 =	hundreds	tens	ones
254 =	hundreds	tens	ones

Add. Check your work.

511	643	431	623	765
215	512	728	750	852
193	388	648	738	504
546	374	450	376	300
176	206	325	425	445
245	262	604	134	609
122	107	292	651	280
$4.25	$7.40	$8.06	$5.14	$7.52
3.12	3.98	1.90	8.52	8.33
2.98	2.79	2.28	6.36	6.34

October 18, 1965

Indicating Processes

On the first line under each problem write an A if you add to solve the problem; or an S if you subtract. Write the answer on the second line.

1. Ted went to the grocery store for his mother. He bought a pound of butter for 72 cents and a dozen eggs for 48 cents. How much did he pay for both the butter and the eggs?

_____ _____

2. Ruth wanted to buy a book that cost 95 cents. She had only 69 cents. How many more cents did she need?

_____ _____

3. Caroline has read to page 119 in her history book. The book has 268 pages in it. How many more pages does she have to read?

_____ _____

4. Hilda and Stella made sandwiches for a class picnic. They made 38 peanut butter sandwiches and 42 cheese sandwiches. How many sandwiches did they make?

_____ _____

5. One Sunday morning John took 55 papers to sell. In two hours he had sold 46 of them. How many papers did he have left to sell?

_____ _____

6. Helen and Vivian ate lunch at the school cafeteria. Helen's lunch cost 36 cents; and Vivian's lunch cost 39 cents. How much did they pay for both lunches?

_____ _____

October 20, 1965

Subtract

300	800	400	500	402	700	300	200
107	448	394	129	359	292	65	172
900	901	405	700	306	800	907	651
815	608	239	81	7	98	489	289
946	305	955	967				
79	268	256	469				

Add

53	24¢	9	25¢	86
14	30¢	497	19¢	9
22	25¢	298	43¢	30
				27

433	544	989	673	646	349
688	787	134	445	133	121
768	138	464	898	748	900
943	494	555	343	626	134

349	986	683	1055	711
+688	+737	+405	+9033	+636
-404	-198	-176	-10088	-366

October 25, 1965

Borrowing Tens in Subtraction

	hundreds	tens	ones		Regrouped hundreds	tens	ones
751 =	7	5	1	=	7	4	11
423 =	4	2	3	=	4	2	3
328					3	2	8

or

300 + 20 + 8 = 328

By regrouping 751 into 7 hundreds, 4 tens, and 11 ones, you can subtract 3 ones from the 11 ones.

Put the missing numbers in each example. Regroup if necessary. Write the remainders.

	hundreds	tens	ones	Regroup hundreds	tens	ones
581 =						
423 =						

673 =
315 =

Write two examples. Solve each one.

Write the remainders for these examples.

962	841	757	472	375
643	514	238	249	149
993	865	736	688	556
728	426	317	239	329

October 25, 1965

Practice in Borrowing

Write the number sentences for these problems in the work space.

1. Roy and John received 227 birthday cards. If 100 of them were sent to John, how many cards did Roy receive?

_____

2. Jack and Larry own 316 hens. Jack owns 107 of them. Larry owns _____ hens.

3. Sue and Kay were in the garden. Sue picked 94 flowers and Kay picked 85 flowers. How many more flowers did Sue pick than Kay?

_____

4. Mr. Brown had 243 television sets in his warehouse. He sold 127 of them. How many sets remained to be sold?

_____

5. Bess had $1.45 when she went to the store. She spent $1.28. Bess had _____ left.

6. The girls in Mary's class had 224 bags of peanuts to sell at a school festival. If they sold 119 bags, how many bags of peanuts remained to be sold?

_____

7. Henry picked 44 tomatoes from his garden. He sold 18 of them to Mrs. Jones. Henry had _____ tomatoes left.

October 27, 1965

Regrouping Twice in Addition

157 =	1 hundred	5 tens	7 ones
341 =	3 hundreds	4 tens	1 one
684 =	6 hundreds	8 tens	4 ones
1182 =	10 hundreds	17 tens	12 ones

or

11 hundreds 8 tens 2 ones

or

1100 + 80 + 2 = 1182

You regroup the 12 ones into 1 ten and 2 ones. Add: 17 tens + 1 ten = 18 tens. Regroup the 18 tens into 1 hundred and 8 tens. Add: 10 hundreds + 1 hundred = 11 hundreds.

Write an example. Solve the example.

	= hundreds	tens	ones
___	= hundreds	tens	ones

Add and check.

476	243	113	301	200
383	765	426	285	794
521	189	589	467	568
215	231	365	470	617
451	845	406	554	700
624	126	534	137	125
820	800	293	405	520
742	900	240	689	940
139	300	607	570	860

October 27, 1965

Addition and Subtraction Problems

Write the number sentences for these problems in the work space.

1. One noon 243 pupils in Eisenhower School went to see the motion pictures shown in the school. There were 398 pupils who did not see the pictures. There were _____ pupils in Eisenhower School in all.

2. The fifth-grade boys of Washington School sold 249 tickets for their school play. The girls sold 315 tickets. The girls and boys sold _____ tickets.

3. Mr. Howe took moving pictures in two national parks on a trip through the West. In one park he used 275 feet of film and in the other 355 feet. How many feet of film did he use?

_____

4. During the entire trip Mr. Howe used 580 feet of colored film and 590 feet of black and white film. How many feet of film did Mr. Howe use?

_____

5. Mr. Hurff has two steers to sell. One weighs 965 pounds and the other weighs 848 pounds. The two steers weigh _____ pounds.

6. Mr. Berger bought 575 dozen shirts one month and 345 dozen the next month. How many dozen shirts did he buy in two months?

_____

October 29, 1965

1.	6.14 -4.09	4.77 -.90	2.53 -1.54	9.67 -6.78
2.	8.56 -7.89	6.57 -6.48	8.68 -8.59	6.81 -6.75
3.	4.68 + 10.05	2.26 + 7.15	1.45 + 7.25	4.86 + 5.63
4.	2.75 8.45 5.96	4.87 9.55 3.07	.08 7.53 .89	8.73 .17 9.10
5.	1.36 -1.27 +4.63	9.45 -9.38 +9.78	34.59 -26.50 +13.98	17.23 -8.29 +8.94
6.	700 -563		500 -258	400 -399
7.	704 -629		500 -417	800 -72
8.	-289 362		-482 118	-79 867
9.	305 - 37		300 - 297	955 - 699
10.	53 14 22	2[illegible]¢ 30¢ 25¢	.25 .19 .43	9 + 497 + 298 =

November 1, 1965

Regrouping in Addition

45 =	4 tens	5 ones	Add the ones.
37 =	3 tens	7 ones	5 + 7 + 6 = 18.
86 =	8 tens	6 ones	Add the tens.
168 =	15 tens	18 ones	4 + 3 + 8 = 15.
	or		
	16 tens + 8 ones		Regroup the 18 ones into
	or		1 ten and 8 ones. Add the
	160 + 8 = 168		1 ten to the 15 tens.

Put the missing numbers in each example. Write the sums. Regroup if necessary.

84 =	tens	ones	93 =	tens	ones
37 =	tens	ones	29 =	tens	ones
25 =	tens	ones	36 =	tens	ones

Write the sums for these examples.

36	35	65	45	44
53	18	80	93	86
24	92	37	76	70
47	80	76	54	66
30	46	92	25	22
65	54	18	87	88

Fill in the missing numerals.

77 + 48 = (70 +) + (40 +)
= +
=

68 + 37 = (+ 8) + (+ 7)
= +
=

November 1, 1965

Problems

Write the number sentences for these problems in the work space.

1. Fred helps his father sell vegetables at his roadside stand. He sold 48 ears of corn on Thursday and 56 ears on Friday. Fred sold _____ ears of corn in two days.

2. Mr. Wilson sowed wheat in three fields. He sowed 18 bushels in the first field, 26 bushels in the second field, and 43 bushels in the third. How many bushels of wheat did Mr. Wilson sow?

_____

3. Alice went to the store for her mother. She bought a bag of sugar for 55 cents and a dozen eggs for 49 cents. Alice paid _____ for the sugar and eggs.

4. Dick joined the Cub Scouts. He paid a fee of 75 cents. He bought a Cub Scout neckerchief for 65 cents and a slide rule for 15 cents. How much did he spend in all?

_____

5. The Cub Scout pack to which Dick belongs has four Dens. In his Den there are 9 boys. In another Den there are 7, in another 6, and in another 10. How many boys are in the Cub Scout pack?

_____

6. Mr. Jacobs had 59 ducks. He bought 8 more. He then had _____ ducks.

November 3, 1965

United States Money

\$4.54 5.86 \$10.40	In addition, put the dollar sign and cents point in each sum. In subtraction, put the dollar sign and cents point in each remainder.	\$14.35 7.46 \$ 6.89

Add and check.

\$3.56 4.35	\$2.24 8.86	\$6.03 3.67	\$6.85 3.87
\$5.23 2.75 1.64	\$6.32 4.50 3.94	\$7.28 4.63 1.80	\$5.48 7.92 6.09
\$2.41 .38 4.63	\$ .67 9.95 .18	\$5.26 6.38 .08	\$7.90 .85 .38

Subtract and check.

\$7.72 6.49	\$8.48 7.05	\$6.72 3.47	\$9.98 8.74
\$4.95 2.96	\$8.43 2.67	\$5.06 3.28	\$7.54 4.65
\$10.42 8.36	\$8.00 5.42	\$12.45 9.38	\$9.00 6.51

November 3, 1965

Dealing with Money

Write the number sentence for each problem in the work space.

1. Sue had $3.75 in her savings bank. She put $.65 more in her savings bank. Sue has _____ in her savings bank.

2. The fifth grade donated $7.95 to the Junior Red Cross. The fourth grade donated $4.86. How much more did the fifth grade donate than the fourth grade?

_____

3. Russell spent 15¢ for a ball, 30¢ for a whistle, and 25¢ for a bell. Russell spent _____ in all.

4. Jerry bought a book for $1.75, some paper for 15¢, and a notebook for 20¢. How much did he spend in all?

_____

5. William is saving money to buy a new baseball suit. He saw one that costs $12.95 and one that costs $9.49. William can save _____ by buying the less expensive suit.

6. Terry bought a bicycle tire for $2.49. How much change should Terry receive from a 5-dollar bill?

_____

November 5, 1965

Subtract

384 285	294 107	834 287	654 129	302 123
468 279	8500 685	200 34		892 346

Add

8700 1056	6764 9105	2624 4765	3456 7831	4597 6601
302 204 60 180	701 492 231 387	216 321 105 132	524 130 206 400	353 215 400 604

Find the missing number

61 - ___ 36	11 - ___ 5	42 + ___ 59	+73 100	+65 90	-17 169
44 - ___ 22	65 - ___ 14	+66 80	73 + ___ 80	100 - ___ 99	

Subtract and check.

772 -649	+ ___	848 -705	+ ___	672 -347	+ ___

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